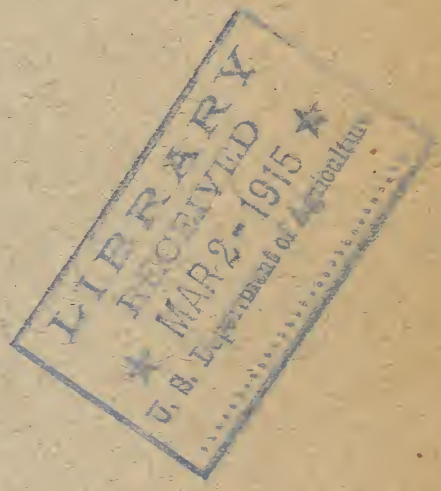
Issued February 20, 1915.

HAWAII AGRICULTURAL EXPERIMENT STATION,
E. V. WILCOX, Special Agent in Charge.

REPORT OF THE HAWAII AGRICULTURAL EXPERIMENT STATION.

1914.



UNDER THE SUPERVISION OF
OFFICE OF EXPERIMENT STATIONS,
U. S. DEPARTMENT OF AGRICULTURE.

WASHINGTON:
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HAWAII AGRICULTURAL EXPERIMENT STATION, HONOLULU.

[Under the supervision of A. C. TRUE, Director of the Office of Experiment Stations, United States Department of Agriculture.]

WALTER H. EVANS, *Chief of Division of Insular Stations, Office of Experiment Stations.*

STATION STAFF.

E. V. WILCOX, *Special Agent in Charge.*
J. EDGAR HIGGINS, *Horticulturist.*
W. P. KELLEY, *Chemist.*
C. K. MCCLELLAND, *Agronomist.*
D. T. FULLAWAY, *Entomologist.*
W. T. MCGEORGE, *Assistant Chemist.*
ALICE R. THOMPSON, *Assistant Chemist.*
C. J. HUNN, *Assistant Horticulturist.*
V. S. HOLT, *Assistant in Horticulture.*
C. A. SAHR, *Assistant in Agronomy.*
F. A. CLOWES, *Superintendent Hawaii Substations.*
W. A. ANDERSON, *Superintendent Rubber Substation.*
J. DE C. JERVES, *Superintendent Homestead Substation.*
J. K. CLARK, *Superintendent Waipio Substation.*

LETTER OF TRANSMITTAL.

HAWAII AGRICULTURAL EXPERIMENT STATION,
Honolulu, Hawaii, July 30, 1914.

SIR: I have the honor to transmit herewith and to recommend for publication a report of the Hawaii Agricultural Experiment Station, 1914.

Respectfully,

E. V. WILCOX,
Special Agent in Charge.

Dr. A. C. TRUE,
Director Office of Experiment Stations,
U. S. Department of Agriculture, Washington, D. C.

Publication recommended.
A. C. TRUE, *Director.*

Publication authorized.
D. F. HOUSTON,
Secretary of Agriculture.

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REPORT OF THE HAWAII AGRICULTURAL EXPERIMENT STATION, 1914.

SUMMARY OF INVESTIGATIONS.

By E. V. Wilcox, *Special Agent in Charge.*

BUILDINGS AND GROUNDS.

The glass propagation house which was erected for use in propagating delicate cuttings and seeds was originally fitted with a water tank on one side which was covered with glass. This was intended as a sun heater, the water circulating through pipes under the propagation beds and connected with the tank on the outside. It proved unsatisfactory, however, and a rearrangement was made by which a gasoline heater was sunk into the ground alongside of the propagating house. This arrangement has given satisfactory results.

The sedge commonly known as Japanese nut grass (*Cyperus rotundus*) has become generally distributed throughout Hawaii and has proved to be a most difficult weed to eradicate. Several patches of it have become established on the station grounds, in fact it is practically impossible to prevent its accidental introduction through seeds carried by animals or on the shoes of visitors. The remarkable quickness with which the nut grass springs up after hoeing makes it an unusually serious pest in all cultivated fields except in the case of tall crops like cane or pigeon peas which ultimately shade the nut grass out. The apparent destruction of the nut grass by this means, however, is a delusion, for as soon as the crop is harvested the nut grass begins again unabated. The only method by which this pest has been successfully controlled thus far is that of mowing at intervals sufficiently frequent to prevent the weed from forming seeds. If this practice be persisted in for a sufficient length of time, the underground bulbs become exhausted and the plants die. This method, however, is not applicable in cultivated fields. A series of experiments has therefore been devised to test various methods of eradication, such as hoeing, harrowing, cutting, and spraying with arsenite of soda at intervals so timed as to prevent the weed from seeding. It is hoped in this way to find a practical method by which the further spread of nut grass can be prevented.

About 7 acres of land adjoining the station grounds and belonging to the Public Health and Marine Hospital Service were turned over to the station for agricultural use for an indefinite period. Not all of this area has soil adapted to agricultural purposes. The whole tract has been fenced and about 5 acres of land cleared ready for plowing. It may not be possible to put water for irrigation purposes on this land, but the rainfall during the autumn and winter is sufficient for the growth of winter crops of garden vegetables, cereals, and other crops which it is hoped to test out during the coming year.

One of the chief needs of the station at the present time is a tract of uniform soil which can be devoted to permanent plats for experiments with fertilizers and a rational system of rotation. The need of such a set of plats has become more and more urgent. The present location of the station was poorly chosen in so far as prospects for scientific fertilizer tests are concerned. The soil is conspicuously lacking in uniformity. The physical and chemical nature of the soil changes every few rods and the patchiness of the soil on the station grounds as a whole is one of its most obvious features. Outside of pot experiments, the fertilizer experiments of the station have been made on the substations and by cooperative arrangements with pineapple growers who happen to possess large tracts of uniform soil. No matter how smoothly, however, a cooperative experiment may be operated, it suffers from the great disadvantage that it can not be permanent nor extend over a sufficiently long period. A tract of land which would be well adapted to the purposes of permanent fertilizer experiments lies near the town of Wahiawa and within the army reservation of Schofield Barracks. This tract is separated by a gulch from the remainder of the reservation and could, therefore, not be used by the Army for maneuvering. It is hoped that an arrangement may be effected by which the station can secure the use of this land permanently for agricultural purposes. A series of experiments could then be organized and carried on in a systematic manner so that the effects of certain fertilizer applications and certain systems of rotation would be permanently on exhibit as an evidence of the scientific value of the fertilizer experiments undertaken, and of the practical value of the system thus adopted for the use of the surrounding pineapple growers and other farmers. The experiments now in progress on a small tract of land on Wyllie Street, leased by the station, indicate that the results thus far obtained in comparing aeration and nonaeration of the soil between crops of rice are rendered somewhat doubtful by the lack of uniformity of the soil. This tract therefore can not be used for the purpose in question, but must be devoted to other work where uniformity of the soil is not of so much importance.

The growth of the station has brought about the urgent need of another building of about the size and proportions of the present office building. The present office building is needed exclusively for office, library, mailing room, and storage of bulletins. The quarters of the entomologist are at present in the office building. The building in which the departments of agronomy and chemistry are now housed is all needed for the chemical department. The horticultural department occupies a small building not well adapted to the work of the department. A new building of the size of the present office building would furnish room for the departments of agronomy, horticulture, and entomology for a number of years to come.

CHANGES IN THE STAFF.

D. T. Fullaway, at the request of the Bureau of Agriculture of the Philippines, was furloughed for work in connection with that institution from October 15, 1913, to February 28, 1914. He was again furloughed on June 1, 1914, for a period of one year to search for parasites of the Mediterranean fruit fly, under the auspices of the Territorial Board of Agriculture and Forestry. J. E. Higgins was absent on furlough during the whole year for work in connection with the University of Porto Rico. C. K. McClelland resigned to accept a position as agronomist at the Georgia Experiment Station. It is proposed for the present at least to have the assistant agronomist continue the work of that department under the direction of the chemical department in order to affiliate more closely the work along those two lines. A plant pathologist is greatly needed at the station. The funds which have thus far been available were not sufficient to make possible the employment of a man for this purpose. There are a number of plant diseases in Hawaii which need investigation. Prominent among such diseases are a banana disease of unknown nature, anthracnose of mango and avocado, and a blight of potatoes.

SUBSTATIONS.

The problem of greatest importance at the Glenwood substation is that of producing suitable forage and other feeding stuffs for dairy cows. The large tract of land devoted to dairying in the neighborhood of the substation presents some peculiar difficulties which must be overcome. The general peculiarity of the neighborhood is the excessive rainfall, which ranges from 200 to 350 inches per year. Occasionally there are years in which there are not more than 20 days in which heavy rainfall does not occur. Many of the legumes apparently can not be made to thrive under these conditions. The same may be said of certain grasses and other forage plants. It is of course impossible to produce hay under such conditions without

an apparatus for artificial drying. The only possible means of storing feed is a silo. A silo has been erected at the substation and a number of experiments have already been made with the different crops for silage. The making of cane silage has offered no more difficulties than are to be met with corn silage, and cane silage of excellent flavor and well liked by cows has been made. The whole sugar cane, including stem and leaves, may be ensiled, or merely the cane tops. No unfavorable fermentation has been found to take place if the silage is properly packed. The acid in sugar-cane silage at the end of three months was found to be only 0.2 per cent. Excellent results were also had with sorghum and Para grass as silage plants. As a soiling crop, honohono (*Commelina nudiflora*) has come into great prominence. This plant grows wild throughout the Glenwood section and ratoons readily, giving heavy crops in succession, particularly if a top-dressing of manure is added from time to time after cutting.

The pure-bred Guernseys purchased for the substation have given a good account of themselves. The registered bull has been much used for service among the cows of neighboring dairymen with the result that there are now 15 grade heifer Guernseys sired by the substation bull.

The creamery work of the Glenwood substation has been reorganized on a slightly different plan from that which prevailed last year. It was found unsatisfactory to ship milk from Hilo and other distant sections to the substation creamery. The cream showed too high a percentage of acid. While the number of cows in the neighborhood is gradually increasing, there are not enough at present to make practicable a cooperative creamery run by the dairymen themselves. The essential features of the association already formed have been retained in the present organization under the title of the Hawaii Butter Makers' Association. Such members of the association as live at too great a distance from the creamery now make their own butter. The milk from the dairies in the immediate vicinity of the substation creamery is separated and butter made for the actual cost of the operation. All of the butter made at the substation creamery and by all other members of the association living at a distance from the creamery is sold by the secretary of the Butter Makers' Association. This butter has made a satisfactory place for itself on the market in Hilo and in Honolulu.

The Glenwood substation is also carrying on experiments with poultry and ducks. A flock of Rhode Island Red chickens is maintained at the station as a general purpose breed, and White Leghorns are raised for egg production. The system of deep litter brooders is used with pronounced success.

At the Hilo substation experiments with bananas and taro have been continued. A study of the varieties of taro of most economic importance has been made and descriptions are being prepared. This material, together with results of experiments in various methods of propagating taro, various distances of planting, and the use of various fertilizers will be ready for publication as a taro bulletin during the coming year.

The work at the Waipio substation is of a cooperative nature. The main problem for the year was a study of onion production. Red and white Bermuda onion seed was planted directly in drills in the fields on September 23, October 3, October 9, November 13, and December 10. Part of the seed was planted in shallow furrows and part in level culture. The Waipio substation is in a region of low rainfall, but unusually heavy rains occurred this year, filling the furrows with soil and burying the onion bulbs. Considerable thinning and transplanting had to be done throughout this area, and the bulbs buried by washed soil had to be uncovered. The best results were obtained from the sowings in September and October. November and December appear to be too late. Areas on which trash was burned not only produced larger onions, but the onions required only 90 to 100 days from seeding to maturity, as compared with 130 to 160 days on areas not burned. It is planned to carry on some experiments to determine whether it may be economical to heat the soil in the rows by means of a crude-oil blast before planting. The area planted to onions was 8 acres. Most of the soil showed 3 per cent manganese by analysis. From seeding to harvest 23 inches of rain fell. The 8 acres of onions yielded 32,210 pounds, not counting the small onions of pickling size.

At the Nahiku substation the most important result obtained during the year was the demonstration that by means of cuttings from heavy yielding trees, a whole plantation of rubber can easily be obtained with a yield approximately that of the most prolific trees. In the experiments carried out in Nahiku, whole trees of *Manihot glaziovii* of known high yield were sawed into cuttings three or four feet long and planted in the wet soil. The cuttings take root and begin growth very promptly, whatever may be the size of the cuttings. Some of them were 5 inches in diameter.

The roselle experiment was continued during the year with the result that higher yields were obtained than had ever been reported for roselle, approximately 17,000 pounds of fresh fruit per acre. A drying plant has been erected for preparing the material promptly for shipment. Two hundred acres of roselle are now growing, and from the present condition of the plants it is to be expected that a large yield will be obtained at the next picking.

A 10-acre fertilizer experiment on Ceara rubber was carried out during the year. The results of this experiment while interesting are not sufficiently pronounced to warrant the conclusion that fertilizers would pay when applied to rubber in the Nahiku district. The best results both in yield of latex and in growth of trees were obtained from the use of superphosphate and potassium sulphate, without the addition of nitrogen in any form. The soils in question are rich in humus and nitrogen.

At the Homestead substation particular attention was given to the relative economy and profits to be obtained from the growing of various crops, including sugar cane, pineapples, peanuts, field corn, and sugar corn. The results obtained indicated that pineapples yielded the greatest profit, followed by sugar cane and sweet corn. The relative economy from these crops, however, varies from year to year on account of the irregularity in prices. At present the prices offered by the canneries for pineapples are less than the cost of production.

COOPERATION WITH MILITARY POSTS.

During the year the amount of cooperation with military posts has greatly increased. For the most part new work in grading and street making at the Army and Navy posts has made it necessary to secure large quantities of ornamental plants and fruit trees in order to overcome the barren appearance of the new grounds. Along this line of work the station staff has furnished plans, general advice, and a large amount of material for planting. At Schofield Barracks a rather elaborate farming experiment is in progress in cooperation with the station. About 60 acres of land have been planted in legumes, Sudan grass, sorghum, Japanese cane, and other forage plants for the purpose of furnishing green feed for Army mules and horses. As a result of the favorable outcome of this experiment it is likely that the authorities at Schofield Barracks will extend their farm operations for the coming year. The United States Army is one of the largest factors in Hawaii in bringing about the greater development of diversified farming. The Army already uses algaroba meal as a part of its mule and horse ration and will take corn as another portion of the ration as soon as it is produced in sufficient quantities. The Army contracts call for 28,000 pounds of onions per month and 240,000 pounds of potatoes per month. During the past year onions were supplied from local sources for two months only, but potatoes not at all. The Army purchased outside of contract large quantities of eggs, poultry, and miscellaneous farm produce. The military authorities are desirous of having the Territory develop a completely independent source of food supply.

MARKETING DIVISION.

At the 1913 session of the Territorial legislature an act was passed providing funds for this station to be used in furthering the marketing of miscellaneous agricultural crops. The Territorial marketing division was established under the supervision of the station on July 1, 1913. The produce sent in by farmers has increased during the year from $84 to nearly $6,000 per month. The total value of produce received and handled by the marketing division during the year amounts to $26,500, at a cost of $2,000.

The effect of the establishment of the marketing division is apparent throughout the Territory in the greatly increased interest in diversified farming. Heretofore most of the ordinary farm produce consumed in the Territory has been imported. There were only a few farmers who were raising miscellaneous produce, and the small quantity of produce which they raised was totally insufficient to furnish a uniform and satisfactory supply. Dealers in Honolulu, therefore, depended upon the mainland supply. Moreover, the price obtained by farmers for their produce was not sufficient to encourage general agriculture. So unsatisfactory a state of affairs had arisen that the most practical question was not how can a crop be grown, but can it be marketed. The chaotic state of the Honolulu market and high freight rates made it impossible for the farmer to raise miscellaneous produce at a profit.

As a result of the establishment of the marketing division various lines of farming have been developed with profitable results. The shipment of produce from all parts of the Territory to one central market insures a large enough quantity of each kind of produce to occupy a place in the market, and also insures a fairly uniform and constant supply. These conditions having been met, the interest shown in local produce by Army posts, hotels, boarding houses, schools, and other institutions, as well as wholesale dealers, has been gratifying.

The effect of the market has been perhaps most noticeable in the poultry industry. Nearly all farmers who have been interested in this line of work have increased their equipment and the size of their flocks and are prepared to be in a position to supply the demand for eggs and poultry in the Honolulu market. The marketing division issues weekly quotation sheets of the prices which have prevailed during the week on all local produce. These sheets are sent to all interested farmers and to the newspapers of the Territory. Blank forms are also sent out to interested farmers on which they can give the market information as to the amount of various crops planted, when planted, and approximately the quantity and probable time of delivery of the crop to the market. This enables the marketing

division to arrange for sales of produce in advance and thus facilitate the prompt handling of the crop. A list of breeders of pure-bred stock is kept, by means of which farmers can be placed in communication with such breeders and secure breeding stock when it is desired.

The work of the marketing division for its first year indicates two directions in which further development is needed. A branch office is required in San Francisco to handle shipments of fresh pineapples, bananas, coffee, sweet potatoes, onions, beans, kukui nuts, coconuts, and the surplus of any other produce which may be raised in Hawaii. At present the business of growing pineapples in so far as the small independent growers are concerned is almost hopeless. The cost of producing pineapples ranges from $12 to $15 a ton. The price offered by the canners at present ranges from $5 to $11 per ton for first-grade pineapples and one-half those prices for second grade. The only hope for the small grower, therefore, until these conditions are rectified, is to find a good market for his fresh fruit on the mainland. The business of shipping fresh fruit can not be carried on satisfactorily without organization. It has been tried by the pineapple growers too many times with disastrous results. If all fresh pineapples were shipped under the direction of a central office in San Francisco, as a branch office of the marketing division, it would be easily possible to prevent a regular succession of bare and flooded markets which have characterized the previous condition of pineapple shipments. Similarly with other produce, a branch office of the Territorial marketing division in San Francisco could create and supply a much larger market for local produce than is now in sight.

Another direction in which the work of the marketing division could profitably be extended is in the line of a retail department. If a cooperative store were established in Honolulu, the farmers of the Territory would be glad to furnish their produce to this store through the marketing division in order to secure for themselves a regular sale of their produce at a reasonable profit, and to secure to consumers the possibility of a constant supply of local produce at reasonable prices.

CHEMICAL INVESTIGATIONS.

The effects of heat were studied on twelve different soils of varying types, the soils being heated to 100 and 250° C. and to ignition. On the whole the effect of applying heat to soils was to render plant food compounds and other chemical compounds more soluble. The most important effects of heating soils are apparently included in the processes of flocculation, oxidation, double decomposition, and alteration of soil elements. There was a slight loss of total nitrogen from heating. One of the striking effects was the unusually rapid formation of ammonia after the soil had been heated. Heating soils

seems to bring about rapidly the effects which are otherwise obtained more slowly by aeration. It has been noted in the case of all plants with which experiments have been made that growth is much more rapid on heated than on unheated soils.

Further experiments on the fertilization of rice substantiated the results already obtained along this line. In nearly all of the rice soils of Hawaii ammonium sulphate or some form of organic nitrogen seems to be the fertilizer most needed. Poor growth results from the use of nitrate as a source of nitrogen for rice. Experiments to determine the possible effect of aeration of the soil between rice crops indicated some advantage from aeration, but the experiments were inconclusive on account of the lack of soil uniformity in the experimental plats.

The investigation of the nature of nitrogen compounds in the soil has been continued and the subject studied from various standpoints. The results thus far obtained indicate that bacteria cause more rapid decomposition of the diamino acids than of the other groups present in protein. A further study of this subject is being made on pure proteins. The hydrolytic and other decomposition products of proteins will receive further study.

Attention has been devoted also to a study of the physical properties of soils with interesting results. In heavy clay soils all fertilizers used alone or in mixtures at the ordinary rate have been found to check the movement of soil moisture. Sodium nitrate increased the water-holding power of soils and also increased the rate of percolation of the water. Corresponding with this there was a diminution of the capillary rise of moisture. Capillarity was found to be greatest in silty soils, less in sandy soils, and least in heavy clay soils. In all these experiments the increase in the concentration of the fertilizer salts caused a diminution in the capillary movement of water. In ordinary soils all fertilizers diminished the percolation of water through the soils. Lime and magnesia salts checked percolation less than the salts of sodium, potassium, and ammonium. In clay soils chlorids were found to check the flow of water less than sulphates, while the reverse proved to be true in the case of organic soils. In each case the soil which showed greatest capillarity offered the greatest resistance to the percolation of water. It was demonstrated that fertilizers exert physical effects which are perhaps more easily detected and measured than are chemical effects.

In a study of the function of fertilizers in soils it was found that phosphoric acid was fixed to a greater extent than other fertilizers. This fertilizer proved most effective when applied in the most soluble form. While, however, phosphoric acid in soluble form was fixed in the soil to an almost indefinite extent in so far as leaching is concerned, it still remained readily available to plants, as shown by the

decided residual effect of phosphoric acid upon three successive crops grown without additional application of phosphoric acid. Ammonia was fixed to a greater extent than potash, but was less firmly held by the soil, and may become available more promptly. Nitrates were not fixed by Hawaiian soils to any appreciable extent. It was found that there was less loss by fixation in the soils when fertilizers were applied singly than when applied in combination. More deflocculation took place, however, when fertilizers were applied singly.

Continued study of the lime-magnesia ratio in Hawaiian soils brought additional evidence that this ratio is not important in itself. It becomes important only when soluble salts are in great excess or when the soil solution is greatly concentrated and the mineral matters out of normal proportion.

Additional evidence has been accumulated that attention to aeration is especially necessary for the proper growth of plants in Hawaiian soils. No nitrification took place without aeration. In soils which have been left fallow for a year or more there was practically no nitrate nitrogen, but nitrification took place rapidly as soon as the soils were thoroughly tilled.

Volatile antiseptics and heat were found to increase ammonification for a period of two weeks. Nitrification then began after about three weeks, and gradually increased to a maximum. Volatile antiseptics in experiments at the station did not kill protozoa, but these organisms were easily killed by heat. The evidence accumulated in soil work at the station is against the possibility of protozoa being connected with nitrification in soils.

Continued pot experiments with various forms of phosphate have demonstrated anew that soluble phosphates do not leach through the soils, but remain permanently available for plant growth. It was also shown that legumes used as green manure greatly increased the availability of rock phosphate.

Analyses were made of all the common tropical fruits in Hawaii. A special study was made of the changes which take place during the ripening of bananas and papayas. A study was also made of the organic phosphorus of rice. This is of particular importance on account of the extensive use of rice as food. The organic phosphorus compound was found to be formed chiefly in the bran or outer layer of the rice grain.

HORTICULTURAL INVESTIGATIONS.

The attempt to establish a strain of papaya with self-fertile flowers and with male trees eliminated has been continued. The results give promise of complete success within two or three more generations of papaya. The examination of 454 trees of the second generation

of breeding showed that 95⅓ per cent of these trees are fruit bearing trees with perfect flowers. Two male trees were cut off 3 feet from the ground and when the new branches came out it was found that the sex had been changed and that regular, perfect flowers, each bearing fruit, were developed.

From the orchard records kept at the station interesting data are now available regarding the average age at which budded, inarched and seedling mangoes and avocados have come to bearing.

On account of the prevalence of the Mediterranean fruit fly it was found necessary to bag some of the fruit which was needed for experimental purposes. Ordinary paper bags were used for this purpose and proved to be a cheap and efficient means of protecting the fruit.

The local interest in hibiscus continues unabated. A number of new varieties have been originated at the station since the publication of Bulletin 29. Perhaps the most interesting ones are two yellow-flowered varieties originated by self-pollination from pink varieties and a semidouble white. Many worthy varieties have also been produced by private breeders and the types have been sent to the station for description. The pink cotton bollworm has been found to breed quite freely in the pods of those varieties of hibiscus which form seed.

A nearly spineless cactus, supposed to have been introduced into Hawaii by Don Marin, has been grown at the station for several years. An opportunity offered to test the hardiness of this cactus in comparison with a number of other drought-resisting plants and several varieties of Burbank's cactus. All of these plants were set out on the island of Kahoolawe in an excessively dry region somewhat exposed to wind. At the end of six months the place was visited again when it was found that none of the plants had grown except the Marin cactus which was growing satisfactorily. In the few tests which the station has been able to make, this cactus, under dry conditions, has grown about three times as fast as the Burbank varieties.

AGRONOMICAL INVESTIGATIONS.

A variety of Japanese rice known as Bezembo was obtained from James Armstrong, of Pearl City. This variety yielded about the same as the other varieties of Japanese rice with which the station has experimented, but matured about 10 days earlier. Experiments will be continued under more favorable conditions to determine definitely whether the æration of the soil between rice crops is of benefit or not to the growth of rice.

Year by year tests are carried on with various cereals in order to determine what kinds fit in with the agricultural program of Hawaii and what varieties can be recommended for Hawaiian conditions. At low altitudes wheat seems to offer no promise. Rye, oats, and certain varieties of barley make a more satisfactory growth. There is a tendency in barley, however, to stool excessively without forming seed heads. Considerable difficulty has been experienced in carrying African sorghums to successful seeding. Seed eating birds are so numerous that it is impossible to save the seed on sorghum plats without bagging the heads. The heads, however, do not develop quite normally under bags.

Among the numerous grasses which have been tried at the station, Sudan grass and Giant Bermuda grass have perhaps attracted most attention. Sudan grass grows rapidly and produces a heavy yield wherever it has been tried in Hawaii except at high elevations. The greatest growth of this grass was obtained on Molokai, where it reached a height of 10½ feet in 70 days. It ratoons promptly and satisfactorily wherever it has been tried. Giant Bermuda grows with unusual rapidity and gives promise of being a valuable pasture grass. Teff grass (*Eragrostis abyssinica*) and saltbushes may also be added to the list of promising forage plants.

The prevalence of blight renders potato raising a precarious venture. Experiments have been carried on at the station for two years in an attempt to develop a system of spraying which would control this disease. The results are still unsatisfactory but give promise that the disease may be overcome. Both Bordeaux mixture and lime-sulphur preparations have been used. The life of the vines is somewhat prolonged but not sufficiently to enable the potatoes to mature perfectly. There is need of a careful study of this disease by a trained pathologist.

Buckwheat and flax have given excellent results in growth and appearance of the plants and in yield. Little trouble seems to be experienced in the growth of these plants in Hawaii either from insect pests or diseases or even from soil conditions.

ENTOMOLOGICAL INVESTIGATIONS.

On account of the absence of the entomologist from the station on furlough for a considerable portion of the year the only systematic work in entomology carried on during the year was on tobacco insects and vegetable diseases. Many of these pests had been previously studied in Hawaii or elsewhere, but the life history of each pest was gone over again in detail so far as possible. Recommendations based on practical experience were made concerning the possible means of controlling these pests.

MISCELLANEOUS.

The interest aroused by the work of the station on kukui oil obtained from seeds of *Aleurites triloba* is shown by the requests which have come from the mainland and from various European countries for kukui nuts and oil for commercial use. There seems to be an active demand for this oil. About thirty-five paint and varnish firms have stated that they would like to buy this oil, some of them to the extent of 25,000 barrels a year. There has been considerable local interest in the kukui industry. Preliminary surveys have been made to determine the amount of nuts available, and one small plant was erected for expressing the oil. It was found in this plant that 40 gallons of oil could be obtained from a ton of nuts. This amount agrees closely with the results obtained in the laboratory at the station. A company is now being organized to express the oil. One New York firm is looking into the business with the idea of securing all of the available kukui nuts in the Territory for oil production. On account of the high value of the press cake as a fertilizer, it would seem best for the Territory that the oil be expressed in Honolulu. The press cake would thus be maintained as fertilizer, and a considerable amount saved on shipments made to New York.

The use of algaroba meal, the ground pods of *Prosopis juliflora*, is rapidly spreading throughout the Territory. The business now amounts to about $350,000 a year. The supply of algaroba beans, while larger than was at first anticipated, is not sufficient for local demands. There is no necessity, therefore, for seeking an outside market for this material. Some of the ranchers and dairymen are preparing to put up plants of their own. For this purpose a drier recently devised by G. F. Winter, of Lihue, Kauai, will be used. An ordinary alfalfa meal mill will grind the algaroba beans very satisfactorily after they have been dried. The Army in Hawaii uses algaroba meal as one-quarter of the grain ration for horses and mules. The interest in this feed is generally more active than has heretofore been the case. As a result of this increased interest there is little of the product which is allowed to go to waste. On some of the large estates the right to pick algaroba beans for a period of ten to fifteen years has been secured.

The experiments carried on by this station and elsewhere with arsenite of soda as a chemical spray for the destruction of weeds has brought about the general use of arsenite of soda for destroying weeds on rubber plantations and on many of the ranches. During the past year this spray was tested on many of the sugar plantations with excellent results and with a great saving in the cost of weed destruction. Several other plantations are now preparing to use the remedy extensively. On one large sugar plantation it has

been estimated from this year's work that the saving in cost of weeding alone has been about $100,000. In some of this work the formula used by the station has been modified to the extent of using caustic soda in the place of carbonate of soda to combine with the arsenic. The station is carrying on experiments to determine the fate of arsenite of soda in the soil and its possible effect upon nitrification and upon the physical properties of the soil. In pot experiments when arsenite of soda was added to the extent of 0.25 per cent of the soil, it was found to cause a pronounced deflocculation. The amounts used for spraying purposes thus far have showed no effect upon the soil.

In addition to breeding work with papayas the station has investigated the matter of producing papain. It was found that dried papain can be produced at a profit for about $2.50 a pound. Requests have recently been received for 2,000 pounds of the material at that price. A papaya grower on Maui is preparing to produce the material. In experiments at the station it was found that if in the early morning a dozen shallow lengthwise incisions, one-half to three-quarters inch apart, are made in a papaya fruit of good size, enough juice will be obtained to make half an ounce of dry papain. Fruits may be tapped on alternate days five to seven times in all. As soon as the fruit begins to turn yellow the milky juice flows less freely. The tapping wounds heal quickly and the fruit is not injured by tapping; in fact, the flavor appears to be somewhat improved, since a slight bitterness which characterizes the juice is thereby removed. It has been found that the papain is injured if the juice is allowed to come in contact with any metallic substances. The only precautions to be observed are that tapping be done with a glass, bone, or ivory instrument, and that the juice be collected in china or earthenware containers, and promptly dried. From the work along this line at the station it is estimated that papain to the value of $2 can be taken from each tree annually.

The use of dynamite for agricultural purposes, particularly in improving soil conditions continues to increase. The results obtained from dynamiting pineapple plantations at the end of the first picking season are satisfactory. The extended commercial experience indicates that dynamite, to be most effective, should be used when the soil is not too moist. If a charge of dynamite is exploded in a wet subsoil it has a tendency to form a more or less spherical cavity in the soil, packing the soil about the walls of the cavity without shattering the surrounding soil sufficiently. The use of dynamite in lawns is increasing. Many lawns which have stood for years without renovation show poor growth of grass on account of the extreme packing of the soil. Dynamite can be safely used in lawns for loosening the subsoil below and improving drainage.

The station has advocated since its establishment thirteen years ago the general use of legumes for green manuring in all branches of agriculture in Hawaii. Experiments have been carried on continuously with different legumes to learn what species were best adapted to practical use in the Territory. Among the generally cultivated legumes jack beans and lupines have proved most satisfactory. The German lupine has given excellent results at the station and elsewhere. Jack bean has the advantage of being a rapid and vigorous grower, and also of being relatively immune to plant lice and other insects which may check the growth of cowpeas. If the cowpeas were not so highly susceptible to the attack of aphids, it would be the legume to be recommended for green manuring. Under local conditions, however, jack beans or lupines or Mauritius bean must be considered most promising. For several years this station has been experimenting with an introduced leguminous weed known as rattlepod (*Crotalaria saltiana*). This legume is unusually hardy. It thrives in wet or dry districts. It will make a fairly good crop under rainfall of 20 inches and thrives abundantly under a rainfall of 200 inches. The seed will germinate promptly with little attention after scattering broadcast upon the soil. The plant is not useful for feed, but is an excellent green manuring crop. No insects do any harm to the plant except the blue butterfly, which merely reduces the number of pods. The seed of this plant can be readily obtained by offering children 10 cents a pound for it. Some of the independent cane planters, as well as the larger plantations, already have standing offers of 5 to 10 cents a pound for Crotalaria seed to be collected from the roadsides and elsewhere by women and children. The seed can not be obtained through seed dealers, but the supply to be obtained from waste places seems to be adequate for present purposes. The Crotalaria has the advantage over cultivated legumes that the seed may be sown without any previous preparation of the soil and of course without cultivation after seeding. In old cane fields, after the last ratoon crop is removed, the trash may be allowed to remain, as well as all weeds which naturally spring up. In order to increase the amount of plant material in the soil Crotalaria seeds may be scattered among the trash and weeds and even under these conditions the plant will make a satisfactory growth. The demand for jack-bean seed is increasing rapidly. The price offered is 5 cents a pound in ton lots. The supply is quite inadequate, but a number of homesteaders are preparing to grow the seed for neighboring plantations.

As already indicated, legumes are coming into use on sugar plantations to supplement the amount of humus derived from trash. The tendency at present is to abandon the burning of cane trash and to allow all this material to rot on the soil or to plow it under. The

results obtained from this economic use of humus material are so apparent that the practice of burning will probably be abandoned altogether within a few years. On several plantations fields which had become the poorest on the whole plantation gave the largest yield during the past year as a result of plowing under humus-forming material, but without applying excessive amounts of commercial fertilizers.

Analyses were made of samples of coffee from coffee cherries uninfested with fruit fly, badly infested with fruit fly, and also from half-ripe cherries taken four or five days before they would be completely ripe. No chemical differences in the composition of the coffee were noted in these different samples. Coffee was prepared for drinking, however, from all the different samples by three different methods, and the coffee was submitted to several persons for their opinion as to the flavor and other qualities of the different samples. All persons to whom the samples were submitted agreed that the sample from infested fruit was slightly insipid and poor in quality, while that from the fruit not quite ripe was pronounced best in flavor. The only explanation which can be suggested at present for this is the fact that the half-ripe fruit comes to the mill in an uninjured condition, while the cherries from ripe and partly infested fruit are nearly all ruptured and in process of fermentation. The fermentation of the whole cherry rapidly develops a putrefactive odor which apparently affects the flavor of the berry injuriously. As a result of these findings coffee growers are picking their fruit a little greener than heretofore, and are thus securing coffee of better flavor and avoiding the excessive infestation of the fruit fly.

A further test was made to determine whether infestation with the fruit fly might cause a loss of weight in coffee. Using the same number of coffee berries from infested and uninfested fruit it was found that the weight of berries from infested fruit immediately after pulping was 5 per cent less than that of berries from uninfested fruit. The first weight was taken after pulping and allowing the parchment to become dry on the outside. Weighings were made from time to time after removing the parchment and silver skin. It was soon observed that the weights of the two lots of berries began to approach each other. When the coffee came to a constant weight and was considered dry the weights of the two lots were the same. It would appear, therefore, that little or no loss of weight in the coffee berry is caused by infestation of the fruit fly.

An unusual amount of damage from rats on the island of Molokai led to a test by the station of the value of a rat virus in destroying this pest. The virus was distributed about a year ago. Dead rats were found within a week or two near all the points at which the virus was

distributed and have been found whenever search was made up to the present time. Apparently the infection has persisted for a whole year with the result that the number of rats has been reduced about one-half. No evidence has appeared that this disease which persists among rats can infest other animals.

Experiments are now in progress to determine the applicability of cold storage to various tropical fruits. It has already been found that holding fruit infested with the fruit fly for a period of ten days at a temperature of 32° F. destroys the fruit fly in whatever stage it may be present. Perhaps cold storage will be accepted as a sufficient means of rendering fruit such as avocados safe for importation into the United States. It has been demonstrated that avocados may be held without injury to the fruit at a temperature of 32° F. for at least two months. The same has been found to be true for star apples and water lemons. Figs have been held for one month at 32° F. with beneficial results to texture and flavor of the fruit. Pineapples came out of a month of cold storage at 32° F. with excellent flavor. The only fruits which have thus far shown a tendency to absorb a disagreeable cold-storage flavor are papayas and mangoes.

Frequent attempts to produce alfalfa hay in Hawaii have yielded rather unsatisfactory results. It seems impossible to secure a good quality of hay. Usually, alfalfa can not be dried in the open air in Hawaii so that it will not heat and mildew when stored. Plans are now being made to dry alfalfa by the devices which are already used for drying algaroba beans. A test of one of these machines on a small scale produced an excellent quality of alfalfa hay which was later ground into meal. The meal was greener and less bleached than the ordinary alfalfa meal imported from the mainland.

A disease of bananas has been observed in Hawaii for many years and has sometimes been mistaken for the Panama disease. It, however, obviously differs from the Panama disease. Infested leaves show spores of a Fusarium, and at the border line between healthy and diseased tissue a bacterial organism was found by Dr. H. L. Lyon in nearly pure cultures. The most obvious symptom of this disease is the death and decay of the terminal young leaves or at least a yellowing and wrinkling of these leaves. Infected plants do not produce the ordinary large leaves, but narrow, yellow, wrinkled ones. Small distorted bunches of fruit may also be formed. These bunches do not fill out properly. It has been found that where the disease is neglected it may gradually become more serious and infect a large percentage of the plants on a given plantation. Spraying with fungicides appears not to be effective, since the fungus is already within the tissues of the plant before the disease can be detected by its symptoms. If, however, diseased plants are cut out and destroyed by fire as soon

as they are noticed the disease can be cheaply and effectively held under control. The disease in question seems to affect chiefly the Chinese banana.

During the past year the hen flea (*Sarcopsylla gallinacea*) appeared in Honolulu and has been spreading rapidly. It is found on chickens, rats, cats, and perhaps other animals, and a bad infestation may kill the young chickens. The fleas are similar to the dog flea and have the habit of burying their heads in the skin of young chickens about the eyes and neck and under the wings, where they remain attached like ticks. A number of remedies were tested in attempts to destroy this pest of young chickens. The remedies included carbolated vaselin, containing 2 per cent of carbolic acid; kerosene; zenoleum in a 3 per cent solution, and carbolic acid in 1, 2, and 3 per cent solutions in glycerin and water. The remedies were applied to the heads of young chickens by means of a small brush. The hen flea is evidently very resistant to contact insecticides. About 75 per cent of the fleas were killed with a single application of kerosene. All of the fleas were killed by an application of carbolated vaselin and a 3 per cent solution of carbolic acid. Zenoleum in a 3 per cent solution was about as effective as kerosene. The pest is found in the soil about infested yards and in cracks of buildings. The trouble is so serious that poultry raisers should thoroughly spray infested yards. Since rats may also carry these fleas, this constitutes one more good reason for a warfare on rats.

During the year the following publications were issued by the station:

Annual Report for 1913.
Bulletin 29, Ornamental Hibiscus in Hawaii.
Bulletin 30, The Effect of Heat on Hawaiian Soils.
Bulletin 31, Rice Soils of Hawaii.
Bulletin 32, The Papaya in Hawaii.
Bulletin 33, The Organic Nitrogen of Hawaiian Soils.
Bulletin 34, Tobacco Insects in Hawaii.
Press Bulletin 45, An Experiment in Marketing under Territorial Auspices.
Press Bulletin 46, Poultry Management.

REPORT OF THE CHEMICAL DEPARTMENT.

By W. P. Kelley.

The work of the chemical department has been continued along the lines mentioned in the last report. The great importance of soils and the many practical difficulties and great expense now incurred in their management and fertilization are sufficient reasons for devoting much study to this subject. The efforts of this department, as in previous years, have, therefore, been devoted mainly to soil investigations. In view of the limited state of knowledge concerning soils and the fundamental importance of the subject, it has been deemed wise to devote considerable time to the investigation of problems of a scientific rather than of a practical nature. In this work effort is being made to find the reason for some of the soil processes that are now only imperfectly understood and to render the common soil practices more intelligible. In this connection studies were undertaken on the bacterial processes of soils, on the physical effects of fertilizers and other chemical substances, and on the availability of phosphates. In addition, a study on the composition of tropical fruits in the islands has been completed, and at present an investigation of the organic phosphorus of rice is being made. A limited amount of time has been devoted to miscellaneous analyses.

BACTERIOLOGICAL INVESTIGATIONS.

The availability of nitrogen in soils is of great importance. There are many forms of nitrogen in soils which previous investigations have shown to be available to plants. Most of these arise from vegetable proteins by the action of bacteria, and are susceptible of further decomposition. Usually investigations on this subject have dealt with ammonification, nitrification, denitrification, and nitrogen fixation, without giving much consideration to the intermediate changes between the complex proteins and the end products. However, since different organic nitrogenous fertilizers become decomposed and converted into ammonia and nitrate at different rates, and in view of the fact that different proteins yield different amounts of hydrolytic products which are of unequal availability and which probably undergo further decomposition at different rates, it is a matter of interest to follow the course of the changes taking place.

The initial decomposition may be assumed to be of a hydrolytic nature and probably to result from the action of bacterial enzyms, but whether *deamidization* is a hydrolytic or oxidative process remains to be determined. From previous work on the organic nitrogen of Hawaiian soils it was suggested that bacteria cause a more rapid decomposition of the diamino acids than of the other groups present in proteins. Extending these investigations to include a study of the bacterial decomposition of nitrogenous fertilizers, it has been found that the basic nitrogen compounds (diamino acids) actually disappear more rapidly than the other groups. The work is being continued with the use of pure proteins.

Closely related to the hydrolytic decomposition of proteins in soils is the ammonification of the hydrolytic products. Investigations will be undertaken on the ammonification of the more common amino acids and acid amids of protein cleavage. In this work special study will be given to the amino acids as sources of energy to bacteria as well as to determine the ammonia formed.

PHYSICAL STUDIES.

Evidence has been accumulated in recent years on the importance of physical factors in soils. From the work in this laboratory and the experience of farmers it is certain that physical factors play a very large part in Hawaiian soils. Soil films and colloids especially appear to play an unusually prominent rôle in their fertility. The striking effects of heat on the growth of plants, the high power for absorbing fertilizers, the importance of aeration, the abnormal effects of lime, and the influence of volatile antiseptics, all seem to be related to colloids. The data already obtained in studies on these subjects emphasize the need for much further study along these lines.

As bearing on these subjects, an extensive series of experiments has been carried out on the moisture relations in soils as affected by fertilizers. Such phenomena as capillarity, percolation, flocculation, cohesion, specific gravity, vapor pressure, and hygroscopic moisture have been studied and an unusually large array of data obtained. A number of different soil types were used and very striking results obtained. It has been conclusively demonstrated that fertilizers do exert measurable physical effects and that there are physical pecularities in Hawaiian soils not hitherto met with. In general, it may be said that no two of the different soils studied were affected to the same degree, and frequently not even in the same order, by a given fertilizer.

The results obtained still leave the subject in an uncertain state. The data must be considered to be empirical, and the conclusion drawn as tentative only. Nevertheless, progress has been made.

The subject is one of unusual complexity and will require the patient efforts of years for its elucidation. However, the conclusion seems to be justified that film pressure and colloids are very important phases of Hawaiian soils, and are affected by fertilizers in some instances to a striking degree. The results of this investigation are being prepared for publication by Mr. McGeorge, assistant chemist.

THE AVAILABILITY OF PHOSPHATES.

Experiments have been in progress for more than a year on the availability of phosphates. This work was undertaken in cooperation with the basic slag committee of the Association of Official Agricultural Chemists, but in view of the practical interest in the subject, the work is being extended to include a wide range of phosphates, using a number of soil types and crops. Hawaiian soils contain abnormal amounts of iron and alumina and are able to absorb unusual quantities of soluble phosphates. Consequently, the availability of phosphates is a question of special interest.

The results to date show that different crops vary greatly in regard to the effects produced by different phosphates. Immediately following the application, different soluble phosphates seemed to affect the growth of millet similarly, while insoluble forms were ineffective. After remaining in the soil some months in conjunction with decaying organic matter, however, rock phosphate became as effective as soluble phosphates, and both forms then gave marked increases in growth. In this work such questions as the reversion of soluble phosphates by lime, the lasting effects of phosphates, the absorption of phosphate by the plant, and the effects of decaying organic matter on availability are being studied.

THE COMPOSITION OF HAWAIIAN FRUITS.

The composition of tropical fruits is a subject of much interest. A number of analyses of such fruit have previously been made, but frequently of fruits that had been shipped over long distances after having been picked. With few exceptions, there are no records of the composition of Hawaiian fruits. Therefore, it was deemed wise to analyze the fruits growing in the islands. In this work the different fruits were allowed to ripen thoroughly on the tree, and were analyzed immediately after picking. The results obtained are therefore of special interest as showing the composition of a large number of normally ripened fruits. A study of the changes taking place during the ripening of bananas and papayas was also made. The results are given elsewhere (see p. 73).

THE ORGANIC PHOSPHORUS OF RICE.

The mineral constituents of foods and feeds are coming to be more seriously considered in nutrition. Among these constituents phosphorus is of especial interest. This element has long been known to occur in plants in both organic and inorganic combinations, but the specific phosphorus compound occurring is a matter of uncertainty. Aside from lecithin and inorganic phosphates, very little until recently was definitely known. From the work carried out at the New York State station and elsewhere, it appears that wheat, oats, corn, and cottonseed meal contain rather large amounts of phytin. In view of the great importance of rice as a food, a study of the forms of phosphorus contained in it is of special interest. This work was undertaken near the close of the year, but interesting results have already been obtained.

REPORT OF THE ACTING HORTICULTURIST.

By C. J. Hunn.

J. E. Higgins, the horticulturist of the station, was away during the past year on leave of absence. V. S. Holt and the writer carried on the work as outlined at the beginning of the last year, and attempted but few new lines.

PAPAYA INVESTIGATIONS.

This station has received during the past two years seeds of many varieties of papaya, *Carica papaya*. These seeds have been planted and many of the seedlings are growing at the station. Others have been distributed among private individuals. In the latter case, the station reserves the right to select the best trees and to propagate from these superior varieties. Many of these trees are now coming into bearing.

Mr. Holt has presented elsewhere [1] a more complete report of the types of papaya flowers and fruits found in the F_2 generation of No. 3198, which were grown from two hermaphrodite flowers fertilized with their own pollen. At the time the report was written only 343 trees were old enough to exhibit sex and fruiting characteristics. There are now 454 trees which show the following types:

Types of papayas grown from close fertilized fruits.

Form No.	Character of fruit.	Number of trees.
1	Pistillate	164
1 and 7	Pistillate and pentandria	1
1, 4, and 9	Pistillate, elongata, and intermediate	2
1, 4, and 7	Pistillate, elongata, and pentandria	2
4	Elongata	108
4 and 9	Elongata and intermediate	2
7	Pentandria	1
8	Pentandria and elongata	148
7, 4, and 9	Pentandria, elongata, and intermediate	5
9	Intermediate	0
2	Staminate	16
3	Correæ	5
	Total number of trees	454

The main object in the breeding and selection of this type of papaya is the elimination of the staminate plants. These 454 trees may be grouped as follows:

	Per cent.
Fruit bearing, exclusive of correæ	95.37
Correæ	1.1
Staminate (sterile)	3.52

[1] Hawaii Sta. Bul. 32, pp. 34, 35.

Since with the dicœcious type of papaya, one theoretically expects 50 per cent fruit bearing, the attainment of over 95⅓ per cent fruit bearing, exclusive of correæ, is a great step in the elimination of the staminate type.

Contrary to expectations, the elongata type has increased in percentage, which gives promise of the ultimate development of a pure strain of uniformly cylindrical fruits. Since this type exhibits general uniformity and is of excellent quality, the work in the future will deal strictly with the elongata type and with the elimination of all the other types of flowers and fruit.

CHANGE OF SEX IN THE PAPAYA.

As noted in a previous publication,[1] the forms of the papaya tend to be variable. The staminate flower of the male trees possesses an undeveloped or abortive pistil. Several authenticated cases of the complete change of a male tree to one purely female have been presented in scientific publications. Previous to this time the station has been unable to present favorable evidence on this point from experiments actually performed in the station's orchards. Early last summer Mr. Holt removed the tops of 22 sterile staminate trees. These trees all made considerable growth and now show the following characteristics: Sterile staminate, 18; correæ, 2; pistillate, 1; and elongata, 1.

The large percentage of sterile staminate trees may be due to the fact that the larger number were of the type of papaya which, under normal conditions, produces equal numbers of staminate and of fruit-bearing trees.

The two staminate trees that changed to correæ appeared in variety No. 2978, in which there are 56.25 per cent pistillate, 12.50 per cent correæ, and 31.25 per cent sterile staminate. The two trees that made the complete change in sex from sterile staminate to one pistillate (see Pl. I, fig. 1) and one elongata, appeared in the F_2 generation of No. 2355:1, in which there are 95.37 per cent fruit bearing and only 3.5 per cent sterile staminate. The two trees that changed sex were the only trees of this type that had been beheaded. As has been noted,[1] there are several possible hypotheses which may account for this change. At present, the only possible explanation of these changes in sex is that there is a preponderant tendency to fruit bearing in No. 3198 and a like tendency to the correæ form in No. 2978.

[1] Hawaii Sta. Bul. 32, pp. 25–27.

MANGOES AND AVOCADOS.

The mango and avocado orchards have been gradually coming into bearing during the past several years. Figures on the bearing age of the various types of trees are as follows:

Bearing age of mango and avocado trees.

	Number of trees.	Average age at time of bearing.		Number of trees.	Average age at time of bearing.
Mangoes:			Avocados:		
Seedlings	48	6 yrs. 3 mo.	Seedlings	27	7 yrs.
Budded	15	3 yrs. 8 mo.	Budded	11	2 yrs. 11 mo.
Inarched	11	2 yrs. 10 mo.			

BAGGING OF FRUIT.

Since the advent into these islands of the Mediterranean fruit fly (*Ceratitis capitata*) many kinds of fruit, on approaching maturity, have been covered with heavy paper bags (Pl. I, fig. 2). The larvæ of *Amorbia emigratella* and of *Cryptoblabes aliena* cause considerable trouble by weaving their webs among the terminal leaves and the flowering panicles of the mango. In order to secure the best fruit it is necessary to remove such webs, as well as diseased and misshapen fruit. While performing these operations but little additional effort is required to place and tie a bag over each fruit cluster. The individual fruits ripen more uniformly but lack the color of those exposed to the sun. Several varieties of the Indian mango have been found to be practically immune to the attacks of the fruit fly.

HIBISCUS.

This station participated in the hibiscus show held during the Mid-Pacific Carnival Week in February, at which time the station's exhibit of varieties, which consisted of Mr. Holt's personal collection of imported and original varieties and those which he has since originated, was unanimously granted the first award. This recognition of the station's collection has created a demand which has been filled in part by the distribution of over 30,000 cuttings and seedlings during the past three months. Mr. Holt has selected the best varieties of hibiscus, and some 200 grafted plants are now being grown in soy tubs for exhibition purposes.

Mr. Holt has outlined a number of experiments in the breeding of hibiscus, one of which is worthy of mention. Yellow hibiscus are exceedingly rare. The process of crossing adopted by Mr. Holt has given a clue as to how this color may be developed. A single orange hibiscus with upright stigmas (39:1) was introduced several years ago from Germany. The F_1 generation (145:1) was self-fertilized

and produced a flower much like its parent. This F_1 hybrid was crossed with 1E (533:1),[1] a single pale cerise flower with white veins and throat and a pale yellow column. The resulting cross, F_2 (102:2), has pale crimson petals with light veins, a dark crimson eye and upright stigmas. The F_2 cross was self-fertilized to produce F_3 (395:1) V. S. H. Parents 1E×Single orange (upright).

The new variety may be described as follows:

Moderate growth, freely branching, brownish bark, green twigs, good foliage.

Leaves ovate, acuminate, serrate, nearly smooth, dark green, 1½–2 inches wide, 2¾–3½ inches long, petiole ¾–1 inch long.

Flower 5 inches wide, scarlet orange with yellow veins, crimson eye, column yellow, crimson at the base, stigmas crimson, appressed, peduncle 2 inches long, bracts 6, green, not spreading, self-seeder.

This hybrid, No. 395:1, has been self-fertilized and also used as the male or as the female parent in a large number of crosses, the seedlings of which will be grafted on thrifty stocks to hasten their flowering.

NEW PLANTS.

A number of years ago the station collected in Honolulu several slabs of an almost spineless cactus. Dr. W. T. Brigham states that he has known this cactus for a long time and that he believes it was introduced by Don Marin. Dr. Brigham suggests that this cactus be called "The Manini Cactus" (the Hawaiian form of Marin). These cactus slabs were grown into plants, which after subsequent subdivision have developed into a hedge nearly 100 feet long. A description of the plant is given herewith:

Opuntia.—Plant averaging 6 to 8 feet in height, shrubby and much branched; basal slabs forming the trunk, averaging 10–14 inches long, 5–6 inches wide, 1¾–2¼ inches thick, joints 2–2½ inches in diameter, smooth and deep green in color, becoming rough and grayish at the joints; mature slabs 10–14 inches long, 4–5 inches wide, ⅜–1 inch thick, narrowing slightly toward the center of the slab, obovate in form, olive green, and inclined to be slightly woody; immature slabs 8–10 inches long, 3–3½ inches wide, ¼–⅜ inch thick, obovate, pea green, and very fleshy; spines absent or at times small and inconspicuous; after being developed into short fleshy leaves, sometimes with spiny terminals, these appendages fall as the slabs mature; when present these spines are two in number, $\frac{3}{32}$ inch long, light gray below, brownish at the tips; spinules absent or very small and basal, 2 to 3, grayish; spinules are numerous and very small in areoles on the fruit; flowers are borne singly at the tips of young branches and consist of a modified joint, bearing at the apex the floral portions, the ovary being buried in a slight depression in the joint; basal joint 1½ inches long, ⅞–1 inch wide, pear-shaped to globose, green, areoles bearing numerous small spicules, floral portion 1½ inches long, 1¼ inches wide, never spreading; petals averaging 25, outer ones short and fleshy, inner ones long and thin, rose to pink in color; stamens and filaments averaging about 300, filaments 1¾–2 inches long, yellowish at the base, carmine above; stigma and style green, stigma 7 parted; style 2 inches long; ovules numerous and contained in the fleshy fruit; the joint changes to a succulent and juicy fruit,

[1] Hawaii Sta. Bul. 29, p. 42.

FIG. 1.—STERILE STAMINATE PAPAYA TREE CHANGED TO PISTILLATE BY BEHEADING.

FIG. 2.—MANGO, SHOWING FRUITS COVERED WITH PAPER BAGS.

FIG. 1.—OPUNTIA, AN ALMOST SPINELESS CACTUS.

FIG. 2.—CLAUSENA LANSIUM, WAMPI.

1½–2 inches long, 1–1½ inches wide, pear-shaped to globose, areoles with numerous small spicules, claret red; pulp deep claret red, many seeds, watery and almost tasteless.

Rapid growth, very productive, and best propagated from slab cuttings, since seed are liable to be cross-fertilized with the spiny Opuntias.

Since this cactus is of rapid growth and comparatively free of spines, it is worthy of attention as an ornamental hedge and as a fodder plant. (Pl. II, fig. 1.)

One of the little-known fruit plants introduced from China is the wampee, whose edible berries are highly esteemed by the Chinese and others. There are about a dozen trees in bearing in Honolulu.

Clausena lansium; C. wampa or *Cookia punctata*. Wampee or wampi. Aurantiaceæ. (Pl. II, fig. 2).—A small tree, 18–20 feet, with luxuriant foliage, native of South China; nearly glabrous pinnate leaves; small dense panicles of whitish sweet-scented flowers, produced in April; fruit ripens in June and July; an edible berry, borne in clusters like the grape, individual fruit nearly globose, the size of a large marble, rough, tough, orangelike rind pale straw yellow in color and covered with glands full of green balsamic oil; seeds 1 to 3 nearly filling the fruit cavity; a small quantity of almost colorless juicy pulp between the seeds and the rind, with an agreeable, aromatic acid taste.

Propagated by seeds and layers. Often used as a dessert fruit, but mostly for preserves. The leaves are used in flavoring. This fruit is subject to the attacks of the fruit fly and should be covered with paper bags.

THE PINEAPPLE SEEDLINGS.

The pineapple seedlings Nos. 3059 and 3060,[1] were transplanted last October from quart tins into 12-inch flower pots. Since the pineapple plant is greatly influenced by the physical character of the soil, considerable black sand was incorporated into the soil mixture. There were 48 plants in lot No. 3059, of which 31 plants are now growing. These plants vary from 1 to 8 inches in height and from 1½ to 14 inches in the spread of the foliage. In character they may be listed as excellent 1, fine 5, good 8, fair 8, poor 8, and very poor 1; no spines 4, very few spines 11, few spines 5, and very spiny 11. There were 53 plants in lot No. 3060 of which 41 plants are growing. These plants vary from 1½ to 12 inches in height and from 2 to 23 inches in the spread of the foliage. In character these plants may be listed as excellent 6, fine 8, good 9, fair 10, poor 5, and very poor 3; no spines 8, very few spines 13, few spines 1, and very spiny 19. In color the leaves of these seedlings vary from green to red and bronze, either as a solid color or in stripes. A number of these seedlings give promise of developing into superior plants and will later be planted under field conditions in order that the character of fruit may be ascertained.

[1] Hawaii Sta. Rpt. 1913, p. 23.

THE PROPAGATION HOUSE.

The solar heater which was originally installed in the propagation house when the latter was reconstructed proved satisfactory only during the afternoons of sunny days. A small gas heater and a water boiler were placed in the propagation house. The hot water did not circulate as rapidly as desired and the benefits were not commensurate with the amount of gas consumed. The plan of having the hot-water pipes in direct contact with the sand also proved unsatisfactory because the sand acted as a nonconductor of heat. The water pipes have been placed in an inclosed chamber just below the sand bed. A concrete pit has been constructed at one side of the propagation house, inside of which has been installed a large gas heater, thermostat, and a boiler. Other appliances, such as water, gas, and safety valves and an auxiliary water container, have been placed in position. Preliminary experiments have proved that this arrangement is efficient, but further work is necessary before definite conclusions may be drawn.

FIELD WORK.

The usual field work of this department has occupied considerable time. The various orchards have been pruned, fumigated, and given general cultural attention. Cover crops were sown at the proper season and were later turned under to maintain the fertility of the land.

ACCESSIONS.

Among the accessions of the past year which are worthy of note are several species and a number of varieties of papaya; budwood of selected local and California varieties of avocado; budwood of the Carabao and Pahutan mangoes; a variety of cucumber with a thick, almost reticulated rind, which is said to be somewhat resistant to insect pests; a species of pipe gourd; a collection of 12 varieties of spineless cactus; several new varieties of sweet potatoes; two new varieties of roselle; and plants of *Lansium domesticum* and three varieties of Garcinia.

This station receives frequent requests for assistance in the selection of agricultural materials. In order to be prepared for such demands, there has been gathered together an excellent collection of American and foreign seed and plant catalogues, spraying machinery and spraying-materials catalogues, farm-machinery catalogues, and catalogues of horticultural tools and requisites.

DEMONSTRATION AND DISTRIBUTION.

There has been an unusual demand for advice and assistance from those interested in homesteads. While this department makes no pretense of keeping a stock of plants and seeds on hand for distribu-

tion, many of these requests have been filled. The principal plants distributed this past year have been seeds and plants of the papaya, the Kusaie lime, and the rough lemon. The quantity of budded citrus and budded and grafted avocados and mangoes has not been sufficient to supply the sale demands. This department has from time to time filled requests made by other scientific institutions.

NEEDS.

The horticultural department is in need of a rat-proof room for the hardening off of new potted seedling plants, a more effective and permanent soil sterilizer, and a large storage space for tin cans and seed flats.

In closing it is desired to express appreciation of the faithful and efficient services of Valentine S. Holt, acting assistant horticulturist, James H. Cowan, assistant, and of those who have done the detail work of the propagating house and orchards.

REPORT OF THE AGRONOMY DEPARTMENT.

By C. K. McClelland and C. A. Sahr.

Work in this department for the year has been carried on along much the same lines as in previous reports. Taken altogether, the results obtained have not been entirely satisfactory on account of weather conditions and pests. The most complete failure was with corn. Corn was planted in November following several good rains, and grew well from the start. Severe winds during January whipped the plants so badly when they were in tassel that no grain was produced. In a plat in which germination was tardy and the plants less advanced, a better result was obtained.

RICE.

The work with rice is being continued on a small scale in Nuuanu Valley. The lines of work include trials of varieties, aeration of the soil previous to planting, rotation, green manuring, and fertilization. Fertilizers have given no definite results on this land for the past two crops, probably due to the richness of the soil. These plats had not been planted for several years, and a considerable amount of grass and roots was turned under in preparing the land for cultivation. The two following varieties have been grown for the first time during the past year:

Bezembo, a Japanese variety obtained from James Armstrong, of Pearl City, and which is grown quite extensively by him. It was brought from Japan by some of his laborers, and it is preferred by them to the Shinriki variety which Mr. Armstrong has also grown from paddy furnished by this station. In the fall of 1913 it yielded about the same per acre as did Shinriki, but slightly less than did Omachi. It blooms and matures in about 10 days less time than either of the other varieties named.

Long Nyah Yin is a Chinese variety obtained from the Oahu Rice Mill Co. It is a short kernel variety and considerably later than the Japanese varieties. However, the Chinese claim that it will produce two crops. It is also said to be as well or better adapted to salt marsh lands as the No. 19 variety heretofore grown on such lands.

The importation of rice into Hawaii continued at about the same rate, the amount for the fiscal year ending June 30, 1912, being

30,000,000 pounds of rice in the brown; for the year ending June 30, 1913, the amount was 32,000,000 pounds. The shipments from Hawaii to the United States during the calendar year of 1912 were 471,793 pounds, and during 1913, 479,920 pounds. The shipments from the United States to Hawaii during the same years were 52,705 and 319,975 pounds, respectively. The shipments to the United States were mainly of Chinese and Hawaiian rice, while those to Hawaii from the mainland were mainly of Texas-grown Japanese rice. In addition to these shipments, the Quartermaster's Department of the United States Army brought in, during the year ended May 1, 1914, 183,000 pounds, previous to which date their supply was obtained locally. The increase of shipments from the United States in more recent times would seem to indicate that many of the Japanese population have concluded to eat more of the cheaper American rice and less of the imported dearer kinds.

SMALL GRAINS.

Wheat, oats, rye, and barley were planted on limited areas. The wheat rusted badly, and although a few heads matured, the results are such as to hold out little hope of successful wheat raising under local conditions. Rye did excellently at first, and more completely covered the soil, and at an earlier date than did any of the other small grains. While the stand was perfect, when the grain headed out, the appearance was that of a thinly planted plat—the number of heads being about 30 per cent of what they should have been. Oats did better than during the previous year, and averaged, when headed out, about 45 inches in height. As with rye and wheat, the number of heads formed was a very small percentage of what one would term a good crop. Oats at the station make rather a slow growth, and lodge badly before maturing. The wide-leaved varieties are particularly subject to rust.

Barley, though slow in its early growth, headed out better than either oats or rye. Both varieties grown headed at the same time, matured in 150 days, and made a growth of 34 inches. The success of this crop is still uncertain, and further trial is required.

The small grains are attacked by rice birds and sparrows, and with these pests in abundance it is impossible to obtain any accurate data upon seed production.

SORGHUMS.

In an experiment with a sweet sorghum, a nonsaccharine sorghum, and Japanese cane for yields of forage over a long period, the sweet sorghum has yielded, in four cuttings, 47.1 tons per acre, and the nonsaccharine variety 49.8 tons in three cuttings. The Japanese cane cut for the first time yielded 102 tons of forage per acre 453 days

after planting. The testing of several varieties of African sorghums for the Office of Forage Plant Investigations at Washington has been attended with some difficulties, such as flood, drought, and severe checking of soil, and the attack of birds. Because of unthriftiness, the first planted sorghums were cut back about September 1, and the ratoon crop allowed to produce seed in the late fall and winter. Because of birds no heads except those covered with wire cloth (held on with spring clothespins) matured, and for that reason very few and often imperfect heads were available for shipment to Washington. A duplicate planting was made on the Wyllie Street plats in October, but these did not reach normal size—heading out early because of cool weather.[1]

SUDAN AND OTHER GRASSES.

Sudan grass planted November 22, 1913, did excellently well. The first cutting, on March 9, 1914, yielded at the rate of 31 tons per acre of green forage; the second cutting, made May 8, was at the rate of 30 tons. The stems of Sudan grass run quite uniformly small and with wide leaves, although occasional plants show a coarseness of stem. The quality of the grass could probably be maintained and improved by roguing out these coarse stemmed plants as fast as they are found, to prevent cross-pollination and consequent deterioration of the seed. With Tunis grass, on the contrary, there is more variability. The majority of the plants have a stem slightly larger than that of Sudan grass, but the leaves are much narrower, and there are many variations with coarse stems and wider leaves. (Pl. III, fig. 2.) Sudan grass is much superior at lower, and Tunis at higher, elevations. At Schofield Barracks the Quartermaster's Department put in about four acres of the Sudan, this being the largest planting as yet made in the Territory. The agronomy department has distributed seed in small amounts to some 40 farmers on the several islands.

New pasture grasses that may prove to be of some value upon lower lands with light rainfall are: Teff grass (*Eragrostis abyssinica*), *Chrysopogon montanus*, and Giant Bermuda. The latter grass has larger stems and leaves and grows more rapidly than does the ordinary manienie. *Chrysopogon montanus* is a perennial grass which has a habit of growth very similar to pili (*Heteropogon contortus*) and it will probably be one of value in the pili country. It will

[1] These long season nonsaccharine varieties of sorghum rarely head out during the warm summer months but seed freely in the cooler fall, winter, and early spring months. No. 309 (S. P. I. No. 25330) when cut Sept. 16, yielded 31 tons per acre of green forage, had no bloom whatever. (See Pl. III, fig. 1.) It and the new varieties now being tested, have been cut twice during the cooler months, the new ratoons heading out again a short time after each cutting. It is possible that dryness during cool weather may influence the bloom somewhat, but it is certain that dryness in hot months exercises no influence. For best yields of seed, however, sorghums should not be cut back in late summer, as was done in the case above mentioned, since with the first rains of the fall, if standing, they grow rapidly and make full crops, but if cut they bloom early with not sufficient growth of plant to fill and mature the seeds.

require the same judicious management as does the pili grass. Teff grass is said to be an annual, but has ratooned freely here during its first trial. From a planting made November 15, 1913, the third cutting of mature grass and seed was made May 27, 1914. The stems are small, the leaves fine, and the entire plant appears to be quite palatable. It seeds freely and will doubtless be able to propagate itself under range conditions much as does kakonakona (*Panicum torridum*).

A number of other grasses were tried out in the grass garden during the year, and although many of them did well, further trial will be necessary in order to determine their value. Mitchell grass (*Astrebla triticoides*), Judd grass (*Leptochloa virgata*), *Paspalum stoloniferum*, molasses grass (*Melinis minutiflora*), *Paspalum virgatum*, *Phalaris bulbosa*, and Texas blue grass are worthy of mention. The American "Buffalo grass" (*Bulbilis dactyloides*) from Kansas seed started very slowly but is making much better growth as the summer months come on. This is one of the best grasses on the Great Plains area of the United States and should be very valuable on the lower dry lands here.

AUSTRALIAN SALTBUSHES.

Several species of Australian saltbushes (*Atriplex* spp.) lately imported into Hawaii are giving satisfactory results as pasture or cover crops for extremely dry and barren localities. Three varieties tested out are the round-leaved saltbush (*A. nummularia*), slender saltbush (*A. leptocarpa*), and gray saltbush (*A. halimoides*). The first-named species has exceptional qualities in its quick, sturdy growth and prolific seeding habits, while the gray and slender saltbushes, though maintaining vigorous growth, are inclined to seed only during the late summer and fall months. However, all have their merits as sturdy, long-period cover crops.

POTATOES.

But few successful potato crops have been harvested in recent years, due to attack from fungus diseases, of which a late blight seems to be the most serious. The stem and root rot, due to *Sclerotinia rolfsii*, which attacks the stem of the vine in its early growth, is generally overcome by deep and thorough cultivation. It has not been determined whether the blight attacking potatoes in Hawaii and the rotting of tubers are caused by the same organism, but on the mainland where potatoes have been killed by blight (*Phytophthora infestans*) resulting tubers were found to be involved in a soft or wet rot, particularly in instances of moist soil conditions. At the station the loss from rotting of tubers has been particularly large when left undug for several days after the killing of the tops by blight.

Difficulties in obtaining full stands have been corrected by entirely discarding the stem end of tubers for seed purposes. Seed treated with formalin by soaking in a solution of 1 pint 40 per cent formalin to 30 gallons of water produced tubers free from scab in every case except when the soil was freshly limed.

Some spraying experiments were conducted during the year. In each instance the spraying was begun when the plants were 6 or 8 inches high, and six to eight applications were given according to the life period of the vines. With White River potatoes no appreciable difference in yields of tubers resulted from rows sprayed with Bordeaux mixture [1] or copper sulphate and washing soda [2] over unsprayed rows, while with Burbank potatoes yields favored the use of Bordeaux mixture. With Irish Cobbler where an 8 : 8 : 60 [3] solution of lime-sulphur spray was applied in the last two applications the yields favored the lime-sulphur over Bordeaux mixture by an 8 per cent increase, the plants maintaining their thrifty appearance two days longer than those sprayed with Bordeaux mixture and twelve days over check rows. When the potatoes are attacked by the potato tuber moth (*Phthorimæa operculella*) or the flea beetle (*Epitrix parvula*) 1 pound of arsenate of lead added to 50 gallons of Bordeaux mixture is recommended.

BUCKWHEAT.

While buckwheat is best adapted to a cool, moist climate, excellent results were obtained from plantings made in early April. Though the blossoming period was attended by excessively hot, dry weather in May, no loss from the blasting of blooms was perceptible. The two varieties under test (Japanese and Silverhull) yielded 25 and 19½ bushels per acre, respectively, in 56 and 63 days. Buckwheat germinates readily and makes good crops in poor soil if well prepared. The ease and quickness of raising this crop recommends its use in regular rotation, particularly as a poultry feed. For best results buckwheat should be sown in drills one foot apart, requiring about one bushel of seed per acre.

FLAX.

Several trial plantings of flax produced good yields of flaxseed, but rather poor yields of straw. Flax requires a light soil well prepared before planting, germinates in 4 days under good conditions, and matures usually in 90 days. It can be drilled or broadcasted, care being taken to insure an even stand when fiber is wanted for manufacture. The average yield of two plantings upon the station grounds was 17 bushels of flaxseed per acre.

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[1] 6 pounds stone lime, 5 pounds copper sulphate, 50 gallons water.
[2] 5 pounds washing soda, 5 pounds copper sulphate, 50 gallons water.
[3] 8 pounds stone lime, 8 pounds sulphur, 60 gallons water.

FIG. 1.—AFRICAN SORGHUM, S. P. I. 25330.

FIG. 2.—SUDAN GRASS ON LEFT, TUNIS GRASS ON RIGHT.

RAPE.

Rape was planted April 5, and grew well at the start. By May 1, when it had gained a height of 10 inches, aphids appeared, and exceedingly hot and dry weather following caused the loss of the entire crop. There seems to be but little doubt that rape will make a good crop when planted at the right season, since it is known that cowpeas, which generally make successful crops, have been killed outright when checked by unseasonable weather conditions together with aphis attack.

LEGUMES.

Of the several legumes introduced during the year German lupine (*Lupinus hartwegii*) gained favor as a green manure crop, yielding at the end of 84 and 96 days, respectively, 9.8 and 18.6 tons green manure and 16.5 bushels of seed per acre. Its habit of growth, while low and spreading at the start, becomes erect and branching as the flower heads appear. Trials with Egyptian clover or berseem (*Trifolium alexandrinum*), Florida beggar weed (*Desmodium tortuosum*), and field burnet (*Sanguisorba minor*) gave fair results, but the field burnet in every trial failed to set blooms and seed. The beggar weed, though known as an annual, has been cut three times, with always a new crop appearing better than the first. Berseem is recommended for higher elevations. The tree lucern (*Cytisus proliferus*), sainfoin (*Onobrychis sativa*), and birdsfoot trefoil (*Lotus corniculatus*) were planted in December, but made little growth until late spring. All but the tree lucern set blooms and pods in May. During early June the sainfoin was attacked by the cottony cushion scale (*Icerya purchasi*), but the plants still held their vigor. In a period of seven months the tree lucern made a growth of 40 inches. The stems are slightly woody, slender, and branching at top.

SUBSTATIONS.

The work at the Kula substation was discontinued at the end of the calendar year 1913. The fall crop of Irish potatoes was a complete failure in spite of spraying. An attempt was made to try out small grains as pasture and green manure crops, the intention being to graze off these crops during the winter months and not to turn them under until time to prepare the land for corn. The crops were turned under, however, after making a good growth in early winter. That these crops will make valuable cover, pasture, and green manure crops at 3,600 feet elevation was fully demonstrated, and it is to be hoped that many in the corn-growing regions will profit by the examples shown them and grow such crops.

At the Waipio substation the agronomy department is interested particularly in a comparison of grain sorghums, Kafir, milo, and

feterita. Heretofore all such crops have failed in this location owing to prolonged drought and unfavorable soil conditions. This season the rains have been more favorable, and better results should be obtained.

SEED DISTRIBUTION.

During the year the demand for seed of field and range crops has become greater than ever before in the history of this department. While the demand for cotton seed has come particularly from the Kona district of Hawaii, seeds of velvet beans, jack beans, lupine, cowpeas, soy beans, peanuts, pigeon peas, corn, broom corn, sorghum, millets, and seeds, roots, and cuttings of lately introduced grasses have been chiefly in demand from homesteading districts throughout the islands.

REPORT OF THE ENTOMOLOGIST.

By D. T. Fullaway.

Little entomological work was done at the station during the year, on account of the absence of the entomologist. From July 1 to October 15 he was on detail with the Territorial Board of Agriculture and Forestry. An account of the work performed under its auspices is contained in a recent bulletin published by that organization.[1] From October 15 to February 28 he was on leave of absence engaged in entomological work for the Philippine government. He was away again from June 1 under the auspices of the Territory. The routine work of the office, however, has been adequately attended to and the insect collection maintained and increased by numerous additions, especially an extensive collection of Philippine insects.

Some further work has been done on the insect pests of vegetables, and there follows an account of the insects found in connection with the cultivation of cabbage, turnip, radish, lettuce, etc. Most of these are common and well-known vegetable pests on the mainland and in Europe, which have undoubtedly been introduced into Hawaii in shipments of fresh vegetables. Because of the great losses they have caused in truck farming they have naturally been the subject of many reports and bulletins elsewhere, and in Hawaii they have been dealt with in the reports of Koebele to the Hawaiian minister of the interior, in the annual reports of this station, and at some length in a report by Marsh.[2] Hardly any new or original matter, therefore, appears in this account, but in view of the economic importance of vegetable crops in connection with a growing population, which will provide a constant and ready market for all that can be produced, it is believed that the information here presented in regard to some of the drawbacks and how in part they may be overcome is desirable and will be useful to growers.

The three principal pests of crucifers in Hawaii are the imported cabbage worm (*Pontia rapæ*), the cabbage webworm (*Hellula undalis*), and the diamond-backed cabbage moth (*Plutella maculipennis*). The cabbage aphis (*Aphis brassicæ* and *Myzus persicæ*) are also bad at times. The serpentine leaf miner, cutworms, and other caterpillars of general feeding habits, as well as grasshoppers and thrips, are pests of minor importance.

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[1] Bd. Comrs. Agr. and Forestry Hawaii, Div. Ent., Bul. 3 (1914), p. 148.

[2] Marsh, H. O. [Bien.] Rpt. Bd. Comrs. Agr. and Forestry Hawaii, 1909–10, pp. 152–159.

THE IMPORTED CABBAGE WORM.

The imported cabbage worm is probably as well known as any of the insects which enter into man's domestic economy, and few fail to connect the velvety green caterpillar which feeds so freely on the plants with the large white butterfly which flits restlessly up and down the cabbage or turnip patch. The freedom with which this insect works, in fact, leaves no excuse for ignorance on this point, for often under one's very eyes the butterfly will stop and deposit on a leaf the egg from which the caterpillar later on hatches. It is one of the commonest insects, and it is rare that a cabbage plant can be grown to maturity without being attacked by it. With cabbage grown under field conditions, it becomes an absolute scourge, requiring all the ingenuity, patience, and thoroughness one can possibly develop to cope with it, and as cabbage is the only cruciferous crop cultivated under field conditions in Hawaii, the damage from this insect yearly is very large.

The insect is a well-known European species which became established in eastern Canada, presumably by introduction with vegetables about 1856. Since then it has gradually spread westward and southward in Canada and the United States, reaching Chicago in 1877, the Gulf coast in 1880, and the Pacific slope in 1883. It was first noticed in Hawaii in 1898 and is reported by Koebele [1] to have been introduced with shipments of cabbages from the coast.

The caterpillars are usually found in rather exposed positions on the leaves, which they eat through or gnaw from the edges, giving the outer ones a very ragged appearance. In cabbage which is just heading they often "worm" from leaf to leaf through the head and leave considerable frass behind, which is likely to set up fermentation and spoil the whole plant for any use. Manifestly, the time to deal with these worms is when they are young to half grown, and if the plants can be started in frames under partial cover, so that the butterfly is unable to reach them to deposit its eggs, it is possible to get them well along toward heading with little or no infestation.

The eggs are laid singly on the leaves, usually on the underside, though this is by no means always the case. They are fusiform in shape, placed on end, but with a moderately wide and firm base, are yellow and radiately ribbed, about $\frac{1}{25}$ inch high and readily seen with the naked eye. They hatch at the end of 4 days.

The larva or worm when it hatches from the egg is very small (about $\frac{1}{15}$ inch long). It increases in size rapidly, however, and at the end of 14 days is full grown and ready to pupate. At this time it is an inch or more in length and a velvety green with a yellowish

[1] Rpt. Min. Int. Hawaii, 1898, p. 87.

stripe down the middle of the back and a line of yellow spots on either side near the breathing pores.

The worm often leaves the plant to pupate in the shelter of some convenient object, but the pupa is also sometimes found fastened by a silken girdle to a leaf of the plant. It is about $\frac{3}{4}$ inch long, angular and ridged, in places somewhat spiny, green to gray, flecked with black; the frontal projection is rather long and sharp with two stout spines behind; at the tip are many closely crowded recurved hairs or spines. The pupal stage is from 8 to 12 days.

The adult butterfly has a wing expanse of 2 inches, is yellowish white, marked with black near the tips of the forewings and a black spot on the disk (two in the female); also a similar spot on the costal margin of the hind wing. It has a slow and lumbering flight, but is extremely active, especially on bright days. One female was observed to lay more than 20 eggs in less than an hour without exhausting herself.

Arsenic sprays are recommended to reduce this pest (arsenate of lead or Paris green and lime). Boiling water is also considered good. The spray must be applied to the underside of the leaves as well as the upper; the spraying outfit therefore should be provided with an extension rod.

The tachinid fly, *Frontina archippivora*, is very commonly bred from these worms and it undoubtedly does much to check their multiplication. *Chalcis obscurata* has also been bred from the pupa, and a bacterial disease is quite common among the worms.

THE IMPORTED CABBAGE WEBWORM.

The imported cabbage webworm, although much more obscure in its operations than the common cabbage worm, is nearly if not fully as destructive. It is equally prolific and just as injurious to cabbage and related crops. In fact, it is more to be dreaded than the other species on account of its peculiar habit of attacking particularly the bud, and because of its ability to escape the action of insecticides in the protection of its web. The pest is found in the Mediterranean region and generally throughout the tropical portions of the Old World. It was apparently of early introduction into Hawaii, as examples were taken by Perkins (1892–1895). It was not generally recognized as a pest in the States until 1897.

The eggs are usually laid about the bud, in the axils of the terminal leaves, oftentimes also on the upper surface of the leaves in the hollows formed by the leaf veins. They are extremely small (about $\frac{1}{50}$ inch), oval, not particularly flat, and are yellowish white flecked with reddish spots and microscopically sculptured. They hatch in from 3 to 5 days.

After hatching from the egg the young larva begins to feed on the leaves, especially the young tender leaves of the bud, and usually spins a web about itself between two leaf surfaces. Often it mines into the stalk or midrib of the leaf. The result of its work quite frequently is the complete destruction of seedling plants. Larger plants are either stunted or deformed, so that they can not make a normal growth. The worm is full grown in about 18 days, and at this stage is about ½ inch long, fairly stout and hairy, with head black and body yellowish brown marked with a thin dark-brown stripe down the center of the back and two similar stripes on the sides, the inner of which is wider than the outer.

The worm pupates in the ground in a rather loose cocoon made of particles of soil webbed together with finely spun silk. The pupa is a quite ordinary kind about ⅓ inch long, shining light brown with dark stripe on back, and a bunch of four fairly long recurved hairs at the tip. The pupal stage lasts from 10 to 15 days.

The adult moth has a wing expanse of ¾ inch, is generally gray, the forewings with darker areas about two wavy white lines which cross the disk at about one-third and two-thirds its length. They fly readily, but are more or less obscure in their habits, and are not often seen in the cabbage fields.

H. O. Marsh experimented on the control of this pest with different insecticidal mixtures, but found nothing that could be depended upon, and recommended screening the seed beds and clean culture as the only means of lessening its depredations.[1] He recommends cotton mosquito netting, but the writer has found wire netting more suitable, and the plants should be 5 to 6 inches high and have a vigorous growth before being set out. The braconid, *Chelonus blackburni*, is a very common parasite of this species.

THE DIAMOND-BACKED CABBAGE MOTH.

The diamond-backed cabbage moth takes its popular name from the peculiar diamond-like pattern of the coloration of the moth; the damage to the crop (cabbage, turnip, etc.), is done entirely by the worm, which is now almost cosmopolitan. It probably originated on the Continent, where it first came to notice as a vegetable pest. In the early fifties it was discovered in the United States; later it was found in Australia, New Zealand, South America, and in Africa, at the Cape. According to Koebele, it was an early introduction into Hawaii.

The damage to the plants caused by this pest results from the destruction of the leaves, which the worms, when present in force, quickly riddle with holes. As the species is extremely prolific, the plants are soon shattered, unless in some way protected.

[1] Chittenden, F. H., and Marsh, H. D. U. S. Dept. Agr., Bur. Ent. Bul. 109, pt. 3 (1912).

The eggs are deposited singly in large numbers on the leaves, usually in the hollow alongside a leaf-vein. They are extremely small ($\frac{1}{40}$ inch), flat, oval, lemon yellow, with iridescent, roughened surface, and hatch in 4 days.

The larva, when hatched from the egg, is very small, but increases in size gradually with age. At the end of 10 days it is full grown and ready to spin its web and pupate. At this time it is a remarkably active slender green worm, nearly $\frac{1}{3}$ inch long, somewhat constricted along the body, which bears microscopic dark spots and hairs. If suddenly disturbed it is most likely to wriggle away with some very lively contortions and drop from the leaf, suspending itself by a silken thread. It is at this period of its cycle that the insect is destructive and also most susceptible to attack with poisons, washes, etc., but its concealed position on the unexposed portions of the foliage must be taken into consideration.

The pupa, as already intimated, is partially concealed and protected by a rather unique, loosely woven, wide-meshed web, attached on all sides to the surface of the leaf. It is a little less than $\frac{1}{4}$ inch long, slender, greenish yellow to pale brown, with a few small tubercles on the head and a bunch of spiny hairs at the tip. Within it the moth develops in from 6 to 8 days and emerges by bursting through the anterior end of the case and its web.

The moth is about $\frac{1}{3}$ inch long with the wings closed and measures $\frac{1}{2}$ inch across when these are spread out. It is generally an ashy gray. The forewings, however, are flecked with black on the disc and apex and have a wide black streak extending from the base through the middle for about half their length. Between this area of black and the hind margin the wing is creamy white, the line of separation usually somewhat wavy. The hind wings are a glossy leaden gray, the antennæ and underside of the body almost white.

Sprays are recommended to reduce the damage of this destructive worm in cabbage and turnip fields, and the remedies commonly used for the other cabbage worms (arsenic, kerosene emulsion, and hot water) are effective for this pest as well. The multiplication of the insect is also greatly checked by the hymenopterous parasites, *Limnerium blackburni*.

These three species, which have been especially mentioned, are all, with regard to their food plants, confined entirely to crucifers, although my observation from the beginning has been that the injurious effects in the case of each species are more noticeable in some crops than in others. Thus the cabbage worm (white cabbage butterfly) does more damage to cabbage than to other crops, although turnips and cauliflower are also attacked. The worm of the diamond-backed moth is most injurious to thin-leaved plants and seedlings; on the tough rubbery leaves of cabbage it has hardly any

effect. The webworm does greater damage to root crops—radishes and turnips—on account of its habit of eating out the bud. It also destroys the foliage of thin-leaved plants.

OTHER PESTS OF CRUCIFERÆ.

The best known aphid in connection with crucifers is the common cabbage louse, *Aphis brassicæ*, but in Hawaii this species is much less numerous than another, *Myzus persicæ*, which on the mainland and in Europe is found principally in connection with the peach. The two species are entirely dissimilar, the latter being a naked green louse, while the former is always covered with a whitish mealy coat. The injury inflicted by aphids results from the withdrawal of the cell sap of plants, causing the rapid withering of the leaves, which may be a mere temporary disturbance or fatal, depending on the extent of the infestation. Both species here are effectively controlled by a hymenopterous parasite (*Diæretus rapæ*) and the dry tumid bodies of parasitized individuals are a common sight on the outer leaves of any crucifer. Aphids, therefore, would be considered a negligible factor in the cultivation of cabbage and related crops were it not for the fact that peculiar weather conditions in Hawaii sometimes favor the rapid multiplication of these pests and occasionally seed-bed plants become badly infested with *Myzus persicæ* so that the plants are greatly retarded or killed outright. These infestations may be promptly remedied by spraying the plants with whale-oil soap (1 pound to 5 gallons of water), blackleaf 40 (1 fluid ounce with 3 ounces of whale-oil soap and 4 gallons of water), or miscible oils (directions for the application of which usually accompany the containers).

The serpentine leaf miner is extremely conspicuous in vegetable gardens where thin-leafed crucifers, such as turnips, daikon, shirona, etc., are growing, but is of no great importance as a crop pest on account of the trivial nature of its injuries and its heavy parasitization. It has recently been studied in the United States by the entomologists of the Department of Agriculture, who found that the same insect previously known under several different names attacks a wide variety of plants. It does the same here, and has been found in geranium, nasturtium, and beets in addition to many cruciferous and leguminous crop plants. The insect is a common European pest which has spread eastward into Egypt and westward upon the American Continent. The damage it causes, as already indicated, is slight and comes from the injury to the foliage caused by the mines of the larvæ or maggots. The eggs are laid deep in the mesophyll of the leaf, are white, oval, and almost microscopic in size ($\frac{1}{100}$ inch). They hatch in 4 days. The larva begins its mine from the position of the egg and its progress is indicated by a bleached wandering track

which enlarges with the growth of the maggot and may end in a pocket. The larva is a slender, shining, yellowish maggot about one-eighth inch long when full grown, with spiracular protuberances and black oral appendages which are almost constantly in motion, rasping away the mesophyl. It continues feeding and advancing in the leaf until it is ready to pupate, usually for 9 or 10 days; then it leaves the leaf end and enters the soil. The pupa is inclosed in an oblong, oval puparium about one-twelfth inch long, distinctly segmented, brown, and with prominent spiracular openings in front and behind. The insect remains in the pupal stage for 6 days, at the end of which the perfect insect emerges. This is a small black and yellow two-winged fly so commonly seen hovering about the cabbage patch. The cycle of the fly in Hawaii according to the above data, which were obtained in April, requires from 20 to 25 days. There would probably be some acceleration of the development in the summer and a slight retardation in the winter months.

Three hymenopterous parasites have been bred from the species belonging to the genera Derostenus, Diaulinus, and Chrysocharis. These are usually active enough to keep the pest well checked and no remedial measures are suggested or considered necessary.

Several species of thrips are also commonly found on crucifers but can not be considered of much importance from the growers' standpoint. The commonest is the onion thrips (*Thrips tabaci*), a pale species. Less common is a dark species of Chirothrips.

Cutworms are also occasionally found and are the common garden species which have been repeatedly reported as attacking succulent plants indiscriminately (*Agrotis ypsilon*, *A. crinigera*, and *Caradrina exigua*). A few other leaf-feeding caterpillars have also at times been encountered. *Hymeria fascialis*, *Plusia chalcites*, and the long-horned grasshopper (*Atractomorpha crenaticeps*). All these are adequately controlled by parasites and are not particularly injurious, but if so at all, their prevalence is in the nature of an outbreak which can scarcely be foreseen, is easily checked by arsenic sprays, and at all events is not likely to be of long duration. The melon fly (*Dacus cucurbitæ*) has often been reported infesting the heart of cabbage, but the infestation is not at all common and is considered to be due to abnormal conditions in the plant, and of a secondary nature.

One of the principal sources of trouble in growing cruciferous crops is the absence of clean cultivation. Specific measures of control have been advised in the case of each of the pests above discussed, but these measures relate to infestations which already prevail. Unfortunately, also, they entail considerable labor and expense and are often partly or entirely ineffective. In many cases, moreover, the conditions would be very different if clean cultivation

had been constantly practiced. This applies particularly to the control of the more insidious pests and to districts where cruciferous crops are raised continuously from year to year. In such places the production of cruciferous crops with profit after a time becomes almost an impossibility owing to the cumulative factor in the natural increase of the pest concerned. It is therefore desirable that when the crops are taken off the stumps be pulled and these together with discarded leaves and all other trash in the fields be disposed of so that the insects in them are unable to breed out. This might be accomplished by deep plowing, though the results would undoubtedly be better if the trash were burned or buried several feet below the surface of the ground. This measure is almost essential in dealing with hardy insects in a country where breeding goes on throughout the entire year, and would take the place and bring about the beneficial results in the way of insect destruction attending the long seasons of low temperature in more northern latitudes.

REPORT OF THE SUPERINTENDENT OF THE RUBBER SUBSTATION.

By W. A. Anderson.

The most important developments at the rubber substation were in connection with observations on the latex-bearing qualities of individual trees, the possibility of propagating for these properties, and the suitability of roselle as an intercrop for rubber.

PLANTING CUTTINGS.

The wide variation in the yields of individuals among Ceara (*Manihot glaziovii*) rubber trees, suggests the possibility of developing a plantation by propagating from exceptionally good yielders with a view to eliminating this wide variation, and obtaining a stand on which all the trees will be large yielders. Seedlings can not be depended upon to come true, and, consequently, in 1912, an experiment was planned to determine the feasibility of transmitting high yielding properties through cuttings.

In February, 1912, 200 cuttings of various size were taken from trees that were considered good yielders, and planted on land belonging to The Hawaiian American Rubber Co., in Nahiku. During 1912 broom corn was planted among these trees, and in 1913, roselle, so that they have been fairly well cultivated during the two years. In January, 1914, when the trees were 1 year and 11 months old, they were tapped with a single cut. The new growth on these trees, 1 foot above the original cutting, averaged 10.8 inches in circumference. They yielded 16 ounces washed rubber from one tapping, of one cut per tree. This is equal, in both yield per tree and returns for labor, to the average reported from 6-year old trees unselected, tapped in 1912. The yield from the different trees was more uniform than on the plantations as a whole, and the results indicate that this method of propagation can be successfully employed to transmit desirable latex-yielding properties.

It was also observed, in tapping experiments on 7-year old trees in the fall of 1913, that the best trees yielded as high as 2 ounces wet rubber at one tapping equivalent to about 1.36 ounces dry rubber. By the method employed in obtaining this yield, one man averaged 200 trees, tapping and collecting, per day's work. The number of

these high yielding trees is small, averaging probably not more than one or two per acre over all the plantations. If all the trees yielded in this manner, rubber could be collected at the rate of 17 pounds dry rubber per man a day. At $1 per day, the average wage for tapping, the rubber would cost about 6 cents per pound for tapping alone. Factory expense, packing and shipping, freights, insurance, and commissions should not exceed 15 cents per pound, and in large quantities could be made much less than this. Other overhead charges would depend on the amount of rubber produced, and can be estimated only on the basis of the number of trees tapped and the yield per tree per year. However, at these figures, there would seem to be a fair margin of profit, even at the present price of rubber.

This high yield of the best trees, coupled with the indication that the high-yielding properties can be transmitted through cuttings, suggests a method by which Hawaiian rubber can be produced at a profit even with low prices for the product. By discarding all unprofitable trees, and planting cuttings from these few best trees, plantations can be developed from which rubber can be obtained at a low tapping cost. This experiment at its present stage, indicates only that the trees obtained from cuttings in this way will give more uniform and larger yields than can be obtained from the ordinary methods of planting with seedlings. Whether trees raised from cuttings taken from trees yielding 2 ounces per tapping, will likewise yield 2 ounces per tapping, can be determined only by keeping a record of the trees from which the individual cuttings were made, and comparing the yield from the resulting trees when they shall have reached the age of the parents at the time the cuttings were taken. As the trees from which 2 ounces per tapping was obtained were seven years old, it would take seven years to determine this point definitely. However, since the yield from these 2-year old cuttings equalled the average yield from ordinary 6-year old trees, it would seem reasonable to assume that it was approximately as large as that of the present trees at two years of age. It will be interesting at least to watch these young trees and to note their performance at maturity.

ROSELLE.

Roselle (*Hibiscus sabdariffa*) was planted on a commercial scale between the rubber trees on two of the plantations during 1913. Results indicated that, with a market for the fresh fruit at 3 to 4 cents a pound, this would be a profitable intercrop. At present, however, there is practically no market for the fresh fruit while a limited market does exist for the dried fruit at 30 to 40 cents per pound, which is equivalent to $2\frac{1}{2}$ to $3\frac{1}{3}$ cents per pound for the fresh fruit less the cost of drying.

Even at this price, however, the results of last year's experiment were so promising that five farmers besides two of the rubber plantations are planting this year, with a total area of about 220 acres.

The rubber trees among which the roselle was planted were spaced 10 by 20 feet. The roselle was accordingly planted 5 by 5 feet as the most convenient spacing to utilize the soil in conjunction with the trees. This is rather close planting where the bushes grow as large as in the Nahiku district. In the early plantings on the lower elevations, the plants grew to a height of 8 to 10 feet, bearing the fruit rather too high for convenient picking. These plants yielded, however, at the rate of 10 pounds of fruit per plant, or roughly, 15,000 pounds per acre among the rubber trees. With the same yield per plant, and the rubber trees replaced by roselle plants, we should have had over 17,000 pounds per acre, which is a larger yield than has been elsewhere reported.

During the same year a planting of 25 acres was made in the Kona district of Hawaii, under the supervision of Mr. R. V. Woods, of the Kona Kanning Ko., who reported the results as indicating that, while planted as a catch crop among other things it might prove profitable, it was not profitable as a crop by itself. The failure in Kona was no doubt partially due to the unusually dry season during the period of growth, while the copious rainfall in Nahiku may be partially responsible for the highly satisfactory yield in this district. During the eight months from the time the first seed was planted to the time of harvesting, the precipitation amounted to 109.17 inches. The partial protection from the trade winds afforded by the rubber trees among which they were planted may also have helped to increase the yield. Whatever the causes, the results would indicate that the Nahiku district is well suited to the growing of this fruit among rubber trees.

Considerable difficulty was experienced in drying the fruit. It was at first thought that the drying could be done at ordinary temperature in a drying house built according to the plan given for a tobacco drying house.[1] Harvesting began in November, and during this month 26 inches of rain fell. It was found the fruit would not dry without artificial heat. Consequently, the drying house was equipped with steam heat. While the building was poorly adapted to this method it was found that, at a temperature of 120 to 140° the fruit would dry bone dry in 24 to 48 hours. The proportion of fresh fruit to dried was roughly the same as previously reported from the experiment station grounds in Honolulu.[2]

Picking is the most expensive operation in connection with the handling of the crop. At first the fruit was picked and carried com-

[1] Hawaii Sta. Bul. 15. [2] Hawaii Sta. Rpt. 1909, p. 55.

plete to the drying house, where it was seeded into the drying trays. It was found cheaper, however, to remove the seed pod in the field at the time of picking. This avoids one handling of the entire weight of the fruit, and saves about one-third in the weight that must be transported to the drying house. At the same time, it avoids another handling of the seed pods, which must be removed from the drying house after seeding by the first method, and leaves the green seeds and pods on the field for whatever fertilizing value they may have. With the price of labor averaging $1 per day, it cost 2 cents per pound of seeded fruit to harvest the crop in this way. The saving in handling and transportation was the chief advantage of the second method.

Considerable loss was experienced from cutworms, both in the nurseries and after transplanting. This has been largely avoided this year by protecting the nurseries with ditches, planting as much as possible between the cutworm seasons, and allowing the plants to remain longer in the nurseries before transplanting. Not only the planting in nurseries, but the transplanting should be done between the cutworm seasons as far as possible. If not planted too thickly in the nurseries, the seedlings can be allowed to reach a height of 1½ to 2 feet before transplanting, without serious injury. This has a tendency, however, to make them branch high, and a better size for transplanting is 6 inches to 1 foot. With the seedlings ready in the nurseries, a few can be transplanted and watched a few days for evidences of cutworms. When it is found that the cutworms do not attack these, the transplanting can be done with comparative safety. Losses from this source this year have been negligible.

The work on this crop has shown:

(1) That large yields can be obtained in this locality when planted between rubber trees;

(2) That some means must be provided for drying artificially;

(3) That unless precautions are taken cutworms will cause serious losses, but that this loss can be largely avoided; and

(4) That if the work is all done by hand with tools now available, the crop can be most economically handled by picking and seeding at one operation in the field.

The value of the crop planted this year by five farmers and two rubber companies is conservatively valued at $52,800.

There is some indication that certain of the plants, by proper handling and judicious pruning, can be made to grow and bear a second year. This would seem to be a proper subject for further investigations.

EFFECT OF FERTILIZERS ON THE YIELD OF RUBBER.

The object of this experiment was to determine the advantage, if any, in the use of the ordinary fertilizers to increase the yield of rubber during a tapping season. A block of 1,000 trees was divided into 10 plats, numbered 1 to 10. The odd sections were left unfertilized for check, and the even sections fertilized with equal amounts of phosphoric acid in the form of superphosphate, potash in the form of potassium sulphate, and nitrogen in the forms of sodium nitrate and ammonium sulphate. The trees were measured at the beginning and at the end of the experiment. The sodium nitrate was divided into four applications, but rainy weather destroyed the results of the tapping after the last application, so that the results are tabulated for only three series of tappings with three-fourths of the nitrate.

Ten tappings were made during September, October, and November, and five during February. Sodium nitrate was applied just before each of the tappings. In the three series of tappings, results per tree were as follows:

Effect of fertilizers on yield of rubber.

Plat No.	Fertilizer.	Yield.
		Ounces.
1	No fertilizer	1.54
2	Superphosphate, 375 pounds, and potassium sulphate, 125 pounds	1.57
3	No fertilizer	1.1
4	Superphosphate, 375 pounds; potassium sulphate, 125 pounds; and ammonium sulphate, 375 pounds	1.4
5	No fertilizer	1.32
6	Superphosphate 375 pounds, potassium sulphate 125 pounds, and sodium nitrate 375 pounds	1.4
7	No fertilizer	1.43
8	Ammonium sulphate 375 pounds	1.55
9	No fertilizer	1.44
10	Sodium nitrate 375 pounds	1.48

Comparing the yield per tree from each of the fertilized plats with the average from the two unfertilized plats on either side, plat 2 exceeded plats 1 and 3 by 19 per cent, plat 4 exceeded 3 and 5 by 15 per cent, plat 6 exceeded plats 5 and 7 by 5 per cent, plat 8 exceeded plats 7 and 9 by 8½ per cent, and plat 10 exceeded plat 9 by 3 per cent. Had all the scrap been collected, the nitrate fertilized plats would have made a better comparative showing. The trees on these two plats retained more rubber after each tapping that had coagulated on the trees. This was more noticeable in the case of plat 10, fertilized with nitrate alone.

Following are the girths of the trees in inches, at the beginning and at the end of the experiment:

Effect of fertilizers on circumference growth of rubber trees.

Plat No.	Fertilizer.	At beginning of experiment.	At end of experiment.
		Inches.	*Inches.*
1	No fertilizer	16	17.9
2	Superphosphate 375 pounds, potassium sulphate 125 pounds	15.97	18.5
3	No fertilizer	15.75	19.6
4	Superphosphate 375 pounds, potassium sulphate 125 pounds, and ammonium sulphate 375 pounds	17.23	19.2
5	No fertilizer	16.9	19
6	Superphosphate 375 pounds, potassium sulphate 125 pounds, and sodium nitrate 375 pounds	16.34	18.4
7	No fertilizer	15.55	18.4
8	Ammonium sulphate 375 pounds	14.78	16.5
9	No fertilizer	16.5	18.1
10	Sodium nitrate 375 pounds	15.2	17.7

With the exception of plat 3, the largest increase in girth is in the section fertilized with superphosphate and potassium sulphate. Why it should be greater in this case than in that of the trees fertilized with these fertilizers plus ammonium sulphate or sodium nitrate is hard to say, but the same was noted in measurements of trees on which an experiment was made in 1909 and 1910.

In general, the results show an increased yield resulting from the use of fertilizers. The increase varies from 3 per cent, in the case of nitrate alone, to 19 per cent, in the case of superphosphate and potassium sulphate.

Superphosphate and potassium sulphate, in combination with ammonium sulphate, show a greater increase than the same two in combination with sodium nitrate. Superphosphate, potassium sulphate, and sodium nitrate show an increase of 19 ounces between the first and third tappings. The largest yield per tree was obtained from superphosphate and potassium sulphate. The next largest from ammonium sulphate alone, though this was only 0.07 ounce greater than that obtained from three-fourths as much sodium nitrate. The difference in cost of material and application would perhaps be the determining factor in deciding between these two. The largest difference between the yield of fertilized and adjacent unfertilized trees was also obtained in the case of potassium sulphate and superphosphate.

REPORT OF THE SUPERINTENDENT OF THE HAWAII SUBSTATIONS.

By F. A. Clowes.

HILO SUBSTATION.

BANANAS.

During the year the experimental plat for studying the influence of planting bananas at various distances apart, as described in the annual report of this station for 1912, was replanted. In replanting, a plat was added in which the bananas were 6 by 6 feet apart. This plat will be harvested in the latter part of 1914.

TARO.

A quarter of an acre was planted in taro in February to determine the relative value of three classes of seed, or hule, namely the parent or makua, the oha or seed from large tubers, and the piu, or small tubers. This area had been planted in 1911, and harvested in 1912. It is intended to replant it at least three times before attempting to draw conclusions. In the 1911 experiment, just one variety, the Kuoho was used. In the 1913 experiment the following varieties were used: Kuoho, Eleele, Lehua, Makaua, Papa pulo, and Nana (Ulaipio). The experiment will be a test of some of the standard varieties, as well as a "seed"-selection test. The crop will be harvested in the latter part of 1914.

SCHOOL GARDENS.

The classes in agriculture of the Hilo Union School were given the use of the interspaces between the freshly-planted bananas for six months. Gardening was done on this land under the direction of E. G. Allen, of the Hilo High School. A study of the work done by these classes suggests ideas which promise to be of value in developing the possibilities of teaching agriculture. A half acre of the substation has been set aside for the use of the classes next year and an effort will be made to develop farther the possibilities of teaching agriculture through school gardens.

GLENWOOD SUBSTATION.

In Olaa comparatively few days go by without rainfall. In upper Olaa it is not uncommon for a month to pass with but a half dozen glimpses of the sun. From April 1 till June 30, 1914, eight acres intended for spring planting at the substation lay fallow waiting for suitable weather to render it dry enough to harrow. This is not at all an uncommon occurrence in Olaa as elsewhere on the windward sides of the larger islands, at elevations above fifteen hundred feet. Nevertheless, periods of several weeks will elapse when sunny skies and slight precipitation prevail. There is, however, no definite dry or wet season and all empirical rules regarding the weather probabilities are very uncertain. The conditions are so different from European and American conditions, that there is little recorded experience available to aid in developing a system of agriculture suited to this region.

Farmers in Olaa are adopting a system of agriculture apparently suited to the climate. The popularity of soiling crops such as honohono (*Commelina nudiflora*) and Para grass can be accounted for by the fact that they are perennial and require little cultivation other than top-dressing with manure. Their use is becoming general where any attempt at all is made to supplement the natural pastures by green crops. It is probable that an extension of the present crude system of live-stock farming with honohono and Para grass as the main crops, could be made very profitable. In the summer months there is much more growth than during the winter. Honohono lodges badly and Para grass becomes woody if left in the field after a certain stage of development. To prevent loss of the surplus in summer, some means of storing is needed. The silo offers one means of solving this difficulty. A hay-drying kiln, either under cooperative or individual ownership, would offer an additional means of storing feed, and would also make Para grass hay a possibility. Since practically all the hay used in the Territory is imported it would seem that a ready market is at hand for a great deal of hay which could thus be a by-product of the live-stock farms of this region. The care of manure is a problem that requires study. There is little available litter to be used as an absorbent. It is consequently difficult both to keep cattle clean in the stable and to absorb the liquid manure to make it convenient to handle. Some dairymen are saving the liquid which is voided while the stock are in the stable by running it into barrels and then carrying it out in buckets. While this means is effective it needs modification in the interests of economy of labor. The matter of economical methods of handling this valuable by-product of the live-stock industry merits attention, since the difference between profit and loss in manufacturing and

agricultural industries largely depends upon the advantageous utilization of the by-products.

An island-bred mare of good medium heavy type was purchased in July. The prime object in buying her was to secure a work animal. She has been bred to a large standard-bred stallion.

CATTLE.

During the year the station herd of cattle was increased by the birth of two bull and two heifer calves, all pure-bred Guernseys, eligible to registry. The herd bull, Raymond of Alta Vista, has stood for service throughout the year. All the farmers within reach have taken advantage of this opportunity. A census of the calves in the neighborhood shows that there are 15 grade heifers sired by the substation bull, distributed among 9 different owners.

POULTRY.

In January a small flock of Rhode Island Red chickens was purchased. White Leghorn eggs were also purchased and hatched in an incubator and the chickens reared indoors in deep litter brooders. It is intended to increase the flock of poultry this year, to study problems connected therewith, and by trap-nesting to develop a high egg laying strain in order to supply farmers with more productive laying stock. A small flock of White Muscovy and another flock of Indian Runner ducks has also been purchased.

CREAMERY.

It had been hoped that the cooperation of all the dairymen within reach could be secured for the Glenwood Creamery Co., which was organized with the assistance of the substation. This cooperation was not secured. Sufficient interest had not been developed among the patrons in delivering sweet cream and the grades established proved to be too low. During the warm months of summer the butter lacked keeping quality and the best prices were not secured. It was proved, however, that sweet cream could be delivered without the use of ice by attention to cleanliness and promptly cooling cream to air temperatures. The output of the creamery was only half of what has been hoped for. This made the cost of manufacture double what was expected. It became apparent, therefore, that it was not advisable to continue operating the creamery as a cooperative enterprise. The company therefore resolved itself into a cooperative marketing association in December. To date it has been doing satisfactory work as a cooperative marketing and buying association, and the field of its operations is extending. Ultimately, it may establish a creamery when circumstances justify it. The substation

has rendered it special assistance, because it is a pioneer organization of its kind so far as Hawaii is concerned. It is now so well established that the assistance of the substation is no longer required.

The substation has bought cream from a few neighboring farmers and is making butter to study problems which arise in connection therewith. The butter made is marketed through the creamery company.

CORN AND SORGHUM.

Three acres of corn of the native white variety from Waimea were grown for the silo. A representative row in this field was weighed and produced at the rate of 8.5 tons per acre. Two acres of Early Orange sorghum were grown for the silo. A representative plat of the field was weighed and produced at the rate of 12.5 tons per acre. Part of the sorghum field was allowed to ratoon, and was used for green fodder as required.

GRASSES.

Para grass maintains its lead as the most promising grass for pasture or soiling purposes.

Giant water grass, Natal grass, Italian rye grass, orchard grass, and redtop have all done well and would probably be valuable as pasture grasses.

The area of honohono for soiling purposes has been increased as rapidly as the supply of stable manure permitted. There is now about a half acre which is being cut for stable feeding, daily, and top-dressed with manure after each cutting. Records of the yield are being kept in order to make comparisons with Para and other grasses.

LEGUMES.

Soy beans were sown broadcast on the corn stubble in November. A very poor stand was secured, which was plowed under in January and the ground planted to wheat and kidney beans. These produced a light growth, which was plowed under in March, as green manure. No satisfactory results were secured from any legumes.

EXTENSION WORK.

During the year assistance was rendered in the organization of two associations of cane planters. One was the East Hawaii Cane Planters' Association, an organization of English speaking cane planters, and those interested in sugar cane. The purpose of the organization was to assist in matters of interest mutual to the members of the association. It is intended to work along the lines adopted by farmers' clubs elsewhere.

A federation of associations similar to the above was also formed. This federation adopted the name of "Hilo-Puna Cane Planters' Union." It aims to federate all associations of cane planters, regardless of language and locality. The unit organization paid into the union assessments at the rate of 30 cents per year for each acre cultivated or controlled by the individual members of the associations. The fund thus raised is being used to secure expert assistance from legal and chemical advisers in connection with difficulties that arise in regard to the marketing of sugar cane. The charter members of the union are the Hakalau Sugar Planters' Association, the Wainaku Sugar Planters' Association, the Honomu Sugar Planters' Association, and the East Hawaii Cane Planters' Association. The union is accomplishing much good by overcoming causes of friction between cane planters and mill managers.

During the year six talks were given to the classes in agriculture at the Hilo Boarding School and the Hilo High School.

SILO.

In September a concrete pit silo was built, 12 feet in diameter, and 12½ feet in depth. The bottom is 4 feet below the level of the stable and the top level with the top of the bank at the rear of the stable. This was filled twice, in October and February. A 7-inch hand-power feed cutter, equipped with a pulley and driven by a 1½ horsepower gasoline engine, was used to cut up the fodder. The feed cutter was placed on timbers across the top of the silo so that the cut fodder fell from the machine directly into the silo.

In October the silo was filled with corn, sorghum, and Para grass; in February it was filled with sugar cane, sorghum, and Para grass. Special interest is attached to the ensiling of sugar cane and Para grass, as the use of these two crops in the silo is comparatively new. Sugar cane made excellent silage, very sweet, little more acid than corn silage, with very agreeable odor, and was readily eaten by the stock. Para grass, mixed with a little honohono, also made silage which the stock ate readily, though of a less agreeable odor than other standard silage crops. Both of these crops are big yielders and are promising for cattle feed.

In June a 20-foot redwood silo was placed on top of the concrete silo already in use. This made a silo 32½ feet deep by 12 feet in diameter. This was filled with cane tops in June in cooperation with the Olaa Sugar Co.

THE COMPOSITION OF HAWAIIAN FRUITS AND NUTS.

By Alice R. Thompson, *Assistant Chemist.*

INTRODUCTION.

The analyses on which this report is based were made to gain information upon the chemical composition of the common fruits and nuts which occur in the Territory. The station receives frequent requests for information regarding the composition of ripe fruits of various kinds and regarding the changes in composition which take place during ripening. Almost every fruit consumer has preconceived notions or desires to know more about the nature of his favorite fruits, their nutritive value and possible physiological effects.

Many of the fruits studied by the station have been previously analyzed, but few of these analyses are based on Hawaiian specimens. Moreover, the analyses were made in various parts of the world, in many cases, from fruits which had been shipped long distances in cold storage. The results thus obtained are not strictly comparable, one with another, for the reason that they were obtained by various chemists and by various methods. The variations observed in the published analyses of a given fruit are due to differences in climatic and soil conditions, stage of ripeness, degree of freshness of the fruit, method of analysis, and perhaps to other factors. The analyses reported were all made by the writer according to one uniform method. All the fruits and nuts came from one locality. Only normal, fully ripe fruits were used. They were picked in the morning and analyzed on the same day. The results, therefore, reliably represent the relative percentages of various constituents in an unusually large list of fruits and nuts from one locality.

In the case of the mango, avocado, papaya, and citrus fruits, several varieties of each were analyzed. Interesting variations in the composition of varieties of the same species were found.

The chemical changes which take place during the ripening of fruits are of great interest from a scientific as well as from a practical standpoint. The station had previously studied the ripening of pineapples. A similar study was made of bananas and papayas. Interesting data on the ripening process in these two fruits are herein presented.

METHOD OF ANALYSIS.

The analytical methods employed were essentially those of the official chemists. The total solids were determined by mixing with asbestos and drying at 100° C. In a few cases it was found difficult to determine insoluble solids when the soluble solids were very slow to filter through the linen filter. The fruit sample began to jelly before it all passed through. Usually the determination was made without this difficulty. Acid was determined by titration against fifth-normal KOH, using phenolphthalein as indicator in the uncolored solutions; otherwise litmus paper was used. In clarifying the fruit solutions for sugar determination alumina cream was used in the analyses recorded in the tables on mango and papaya. In all other cases lead subacetate was used instead, since alumina cream proved inefficient in these fruits. Reducing sugars were determined by the volumetric Fehling solution method of Munson and Walker, the more acid fruit solutions being neutralized. Sucrose, with a few exceptions, was determined by Clergat's method. Fat was obtained by extraction with ether. When starch was known to be an especial constituent the total hydrolyzable carbohydrates were determined by acid hydrolysis. Diastase was used in the starch determination in studying the ripening of bananas and papayas.

ANALYTICAL DATA.

In the table on page 66 is shown the composition of several varieties of mangoes. The total solids are high for the average fresh fruit; the total sugars vary from 11 to 20 per cent, according to the variety. In all samples the sucrose is the principal sugar present. The protein in several varieties is a little higher than is usual in fruits. The acidity varies and is as much as 0.5 per cent in one variety.

Qualitative tests showed the presence of considerable amounts of tannin, but no starch was apparent.

The analysis of the avocado shows it to contain rather high total solids. The high percentage of soluble solids is probably due in part to oil which passed through the linen filter. The protein and ash are high for fruit. Very noticeable are the small amounts of sugars and the large amount of fat. The fat varies in the several varieties, being as high as 21.79 per cent in one fruit. The acid content of the fruit is very low.

As the composition of the banana is discussed more in detail later little need be said here about the analyses. They show the high and variable sugar content of the ripe banana, being highest in the baking varieties. The ash and protein are high. The acidity is low, being highest in the Apple banana.

The breadfruit is included in the table with bananas because it contains such high amounts of carbohydrates. In comparing it with the banana the hydrolyzable carbohydrates are seen to be much greater in amounts. The breadfruit contains considerable amounts of starch even when ripe. The ash, fiber, and protein are high.

The Samoan breadfruit was analyzed at a riper stage than the Hawaiian specimen, which may account for the larger proportion of starch to sugars in the former.

The jack fruit, belonging to the same family with breadfruit, and curious because of its huge size and strong peculiar odor, is rather high in protein and fiber and low in acid. The analysis of the total pulp shows less sugar than that of the edible portion, which consists of a yellow custard-like pulp surrounding each seed. The seed of the jack fruit has a very high content of starch and but very little sugar. The protein is over 5 per cent.

The composition of the papaya is discussed below in more detail. In comparing the several varieties the total solids are seen to vary several per cent.

The acidity and protein vary also with the variety as do the sugars. As experiments in breeding new varieties of papayas are being carried out by the horticultural department of this station to develop flavor, sugar, and firmness, these analyses are of interest as showing the changes brought about. It will be noticed that the principal sugar of the papaya is invert sugar, and only traces of sucrose are found.

Citrus fruits are known for their high acid content, which makes them especially refreshing when made into beverages. The common orange is milder than the lime or lemon, containing less acid and more sugar than the latter fruit. Sucrose and reducing sugar are both present in the orange.

The fiber is rather high in the oranges and shaddock. The high fat content in the limes and lemons may in part be due to oil from the skin. The samples were prepared by peeling off the skin in case of the orange and grinding up the whole pulp. The lemons and limes were squeezed as in obtaining the juice, which accounts for the low total solids found.

The samples of guavas analyzed were obtained by grinding up pulp and seeds together, as it is difficult to separate the seed. The skin was removed in all except the strawberry guavas, which are eaten whole.

The sugar content of the guava is not high. The strawberry guava contains more acid than the other varieties, but is less acid to the taste.

The sweet sop and cherimoya contain considerable sugar, principally reducing sugar. The protein and fiber are high and the acid low.

The roselle is of commercial interest, as it is used to a great extent in making jams and jellies which resemble cranberry jelly. The calyx is unusually low in sugars and hydrolyzable carbohydrates and quite high in acid. Its food value is almost nil, but its strong acidity, fine red color, and jellying qualities make it of especial value as a cooking fruit. The seed pods have a somewhat higher carbohydrate content and are less acid.

The tamarind is of interest because of its high acid and sugar content. It is supposed to contain more acid and sugar than any other fruit. The tamarinds analyzed in this laboratory were lower in reducing sugar than those grown in the Philippines, but the fruit may have been slightly green. The analysis reported by Pratt and Del Rosario [1] shows the green tamarind to contain little sugar, but the sugar increases very greatly on ripening.

In the analysis of the pomegranate, sample 1 was obtained by grinding up the pulp and seeds, but in sample 2 the seeds were separated from the pulp.

Of the Hawaiian berries the poha and Hitchcock berries are most commonly used. The poha makes a jam which has an unusually delicious flavor. The berries are quite acid. The ohelo grows wild on the mountain sides and is not cultivated to any extent. It has a low sugar and acid content. The Hitchcock berry is similar to the raspberry.

Prickly pear grows wild on the islands, but the red juicy fruit is not very popular as a food on account of the spines that make it difficult to pick. The fruit is juicy, sweet, and very mild in flavor.

Kamani fruit is used in making an alcoholic liquor, and is very fibrous.

The noni is a bitter fruit with a disagreeable odor; it is much used as a medicine.

Of the nuts analyzed the coconut and kukui are best known. The nuts contain considerable oil and but little sugar. The protein is high in the kukui and cashew nuts, but low in the coconut. The kukui is only eaten in small amounts, as it has a poisonous effect. The cashew requires baking before it can be eaten with impunity.

The table following gives the results of the analyses of 92 samples of Hawaiian fruits and nuts.

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[1] Philippine Jour. Sci., Sec. A, 8 (1913), No. 1, pp. 59–80.

Composition of some Hawaiian fruits, nuts, etc.

Kind of fruit.	Edible portion.	Waste.	Total solids.	Insoluble solids.	Ash.	Acids as H_2SO_4.	Protein.	Sugars.			Polarization.			Fat.	Fiber.	Hydrolyzable carbohydrates other than sucrose.
								Reducing.	Sucrose.	Total.	Direct.	Invert.	Temperature.			
Mango (*Mangifera indica*):	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*° V.*	*° V.*	*° C.*	*Per ct.*	*Per ct.*	*Per cent.*
Pirie	60.00	40.00	20.52	3.14	0.343	0.221	0.456	3.55	11.23	14.78	+ 8.84	−5.45	31	0.032	0.508	.....
Pirie	65.28	34.72	21.02	1.75	.466	.127	.838	3.31	14.02	17.33	+11.8	−6.10	30	.165	.404	.....
Alphonse	67.48	32.52	20.92	2.42	.469	.373	.919	3.74	10.90	14.64	+ 9.7	−4.2	30	.149	.715	.....
Oahu	61.66	38.34	19.61	3.82	.445	.122	.531	2.06	13.66	15.72	+12.4	−4.8	33.5	.....	.713	.....
Totafari	60.19	39.81	15.27	2.11	.277	.578	.475	3.55	7.93	11.48	+ 4.8	−5.2	33.5	.065	.539	.....
Jamshedi	66.25	33.75	20.07	4.35	.415	.264	.944	1.53	11.53	13.06	+10.2	−4.4	32	.133	.656	.....
Gay	59.60	40.40	23.42	4.02	.419	.379	1.075	3.01	16.99	20.00	+14.2	−7.2	33.5	.530	.695	.....
Brindabani	69.75	30.25	19.75	5.88	.274	.269	.438	4.55	10.43	14.98	+ 8.0	−5.2	32.2	.126	.518	.....
Avocado (*Persea gratissima*):																
Makaha I	74.57	25.43	21.01	10.43	1.003	.137	1.456	.83	.00	.83	+ 2.0	+2.4	31.4	13.05	1,282	.....
Makaha II	73.47	26.53	25.87	13.97	1.031	.093	.....	.64	.00	.64	+ 3.2	+3.2	31.5	17.25	1.378	.....
Davis No. 7	64.57	35.43	21.29	13.78	.915	.069	2.094	1.28	.39	1.67	+ .5	.0	33	11.92	1.639	.....
Davis No. 6	51.34	48.66	30.74	20.57	1.038	.078	1.700	.44	.00	.44	+ .2	+ .2	31.8	21.79	1.672	.....
Davis No. 4	63.39	36.61	28.15	18.91	1.034	.104	2.238	.56	.00	.56	+ .6	+1.2	30.5	19.01	1.707	.....
Banana (*Musa* spp.):																
Chinese	70.00	30.00	21.28	2.45	.955	.245	1.788	8.18	8.48	16.66	+ 7.9	−3.2	23.7	.180	.253	None.
Apple	74.49	25.51	31.52	.....	.964	.417	1.238	14.56	9.59	24.15	+ 6.6	−5.6	31	.223	.351	.....
Brazilian	68.25	31.75	27.78	7.21	.924	.406	1.775	17.23	2.45	19.68	− .9	−4.0	31.5	.201	.305	2.57
Baking	75.72	24.28	32.22	5.49	.750	.397	1.350	21.16	5.04	26.20	+ 1.6	−4.8	31.6	.518	.333	2.53
Fehi	64.29	35.71	27.87	10.30	.....	.230	1.069	14.49	.00	[1] 14.49	.....	.....	.....	.046	.594	.....
Breadfruit (*Artocarpus incisa*):																
Hawaiian	77.75	22.25	41.82	20.35	.952	.049	1.575	1.75	7.74	9.49	+ 8.2	−1.6	32	.190	1.204	27.89
Samoan	83.44	16.56	26.89	8.44	1.152	.078	1.575	4.93	9.67	14.60	+10.4	−2.0	29	.517	.978	9.21
Jack fruit (*Artocarpus integrifolia*):																
Whole fruit	57.73	42.27	18.92	8.86	.962	.181	1.688	5.55	2.18	7.73	+ 1.6	−1.2	29	.599	1.904	.....
Pulp	32.00	68.00	23.20	5.76	.934	.274	1.444	6.51	8.64	15.15	+ 7.5	−3.6	28.5	.450	1.311	.....
Seeds	87.00	13.00	50.82	34.94	3.497	.162	5.444	.71	1.16	1.87	+ 1.9	+ .4	28.0	.241	1.609	23.53
Papaya (*Carica papaya*):																
Trinidad (2976)	75.56	24.44	12.14	1.66	.539	.061	.438	8.98	.74	9.72	+ 1.8	+ .86	31	.065	.780	.....
South Africa (2973)	72.29	27.71	13.00	2.32	.549	.098	.681	10.20	.53	10.73	+ 2.4	+1.7	29.2	.074	.818	.....
South Africa (2973)	73.50	26.50	14.06	2.52	.612	.098	.519	10.62	None.	10.62	+ 1.8	+1.76	33.4	.041	.851	.....
Honolulu (2355: 3)	71.75	28.25	12.20	1.81	.560	.078	.500	10.29	None.	10.29	− .4	− .5	31.5	.059	.663	.....
Barbados (2848)	84.11	15.89	11.72	2.44	.481	.069	.463	8.95	None.	8.95	+ .8	+ .86	32.5	.068	.765	.....
Tahit (2975)	74.76	25.24	10.19	2.07	.677	.171	.906	7.50	.94	8.44	+ .7	− .5	31.5	.045	.789	.....
Tahiti (2975)	78.14	21.86	9.50	1.90	.630	.113	.694	6.71	.39	7.10	+ .7	+ .2	30.0	.....	.....	.....
Barbados (2764)	77.47	22.53	10.58	1.88	.517	.103	.731	7.47	.31	7.78	+ 2.0	+1.6	31.0	.055	.754	.....

Barbados (2848)	82.44	17.56	9.22	1.99	.372	.078	.519	6.10	.31	6.41	+ 2.0	+1.6	30.8	.091	.842	
Panama (2979)	47.71	52.29	16.51	1.78	.878	.186	.750	13.21	2.04	15.25	+ 1.0	−1.6	31.0	.115	1.003	
Panama (2978)	48.58	51.42	14.41	2.09	.905	.147	.506	9.86	1.26	11.12	+ 1.8	+ .2	30.5	.253	1.094	
2355	83.39	16.61	10.59	1.05	.565	.059	.388	8.02	None.	8.02	− .2	.0	31.0	.186	6.693	
Orange:																
Kona	72.13	27.87	12.15	2.57	.453	.882	.681	2.09	3.81	5.90	+ 3.5	−1.4	28.3	.387	.575	
Waialua	70.50	29.50	9.56	2.60	.505	1.058	.819	4.25	2.99	7.24	+ 3.2	− .6	31.4	.....	3.66	
Japanese	71.26	28.74	11.20	2.16	.353	.749	.831	3.82	2.83	6.65	+ 3.0	− .6	30.6	.448	.479	
Chinese	68.75	31.25	10.81	3.01	.522	3.758	.....	.....	.....	.....	.....	.....	.....	.303	.777	
Shaddock	42.39	57.61	11.53	6.14	.486	.196	1.175	.86	7.26	8.12	+ 7.6	−1.6	31.8	.140	1.977	
Limes	49.17	50.83	11.75	.11	.352	6.830	.675	1.50	None.	1.50	− 0.4	− .2	31.5	3.561	.065	
Lemons (rough)	33.14	66.86	6.44	.30	.232	3.371	.356	1.53	.47	2.00	+ 2.2	+1.6	32.3	1.49	.084	
Guava (*Psidium guajava*):																
Common	84.69	15.31	17.78	7.27	.531	.363	1.125	6.61	.77	7.38	− 1.8	−2.8	30.2	.524	4.445	
White	87.76	12.24	18.75	7.73	.676	.451	1.525	5.73	2.53	8.26	− .2	−3.4	32.3	.412	5.105	
Trinidad	86.62	13.38	15.43	8.99	.651	.261	1.506	5.79	.55	6.34	− 2.5	−3.2	31.0	.353	4.425	
Guava (*Psidium cattleianum*):																
Chinese strawberry	98.01	1.99	20.08	7.36	.635	.696	.....	3.64	6.37	10.01	+ 4.70	−3.4	31.0	.418	3.868	
Common strawberry	98.60	1.40	18.27	9.97	.743	1.171	1.038	2.41	2.05	4.46	+ 1.8	− .8	31.7	.554	6.146	
Common strawberry	81.16	18.84	23.75	14.47	.755	.715	1.838	2.32	3.31	5.63	+ 2.4	−1.8	32.0	.790	9.378	
Fig: (*Ficus carica*):																
——— ———	80.39	19.61	16.96	2.85	.475	.127	.988	12.98	None.	12.98	− 1.8	−1.6	31.6	.368	1.275	
2384: 1	81.96	18.04	17.72	2.09	.548	.137	1.250	12.75	0.39	13.14	− 1.5	−2.0	33.2	.210	1.149	
Tantalus	78.34	21.66	10.27	2.18	.454	.167	1.963	6.28	None.	6.28	− .5	− .4	30.5	.261	1.073	
Pineapple (*Ananas sativus*) [2]	.....	.....	.....	.....	.....	.66	.375	3.92	6.78	10.70	+ 5.0	−3.6	31.7	.....	.....	
Grape (*Vitis labrusca*):																
Isabella	56.25	43.75	15.73	6.67	.205	.490	.394	16.19	None.	16.19	− 5.0	−4.8	28.7	.238	.289	
Sweet sop (*Anona squamosa*)	53.47	46.53	21.33	4.07	.844	.215	2.038	16.51	None.	16.51	− 3.4	−3.6	31.7	.547	1.632	
Do	55.73	44.27	24.82	5.48	.673	.127	1.531	15.27	2.88	18.15	− .7	−4.4	27.7	.548	1.225	
Cherimoya (*Anona cherimola*)	84.23	15.77	33.81	9.86	.669	.064	1.838	15.34	3.07	18.41	+ .3	−3.6	31.4	.145	4.293	
Star apple (*Chrysophyllum cainito*)	86.90	13.10	11.47	5.46	.392	.127	2.338	2.67	1.73	4.40	+ 1.6	− .6	31.5	1.385	.857	
Mountain apple (*Eugenia malaccensis*)	73.87	26.13	8.61	.....	.137	.068	.213	6.88	None.	6.88	− 2.1	−2.1	29.0	.035	.562	
Rose apple (*Eugenia jambos*)	62.94	37.06	15.85	3.70	.299	.039	.794	11.26	.47	11.73	− 1.2	−1.8	30.3	.189	.982	
Java plum (*Eugenia jambolana*)	57.50	42.50	15.63	3.54	.287	.838	.619	12.99	None.	12.99	− 3.0	−2.8	32.7	.524	.164	
Surinam cherry (*Eugenia michelli*)	84.38	15.62	9.30	1.93	.342	1.440	1.019	4.68	1.38	6.06	− 1.0	−2.8	25.0	.664	.343	
Loquat (*Eriobotrya japonica*)	60.00	40.00	10.02	2.71	.385	.666	.413	1.79	2.09	3.88	+ .5	−2.2	27.5	.500	.653	
Roselle (*Hibiscus sabdariffa*):																
Calyx	55.43	44.57	11.58	5.03	.651	2.263	1.231	.20	None.	.20	+ .4	+ .4	29.0	.819	1.454	1.57
Seed pods	.....	.....	23.73	16.91	1.078	.637	4.000	.27	1.09	1.36	+ 1.0	− .4	29.5	1.152	6.621	4.18
Ceriman (*Monstera deliciosa*)	73.88	26.12	22.12	2.12	.851	.353	1.181	16.19	None.	16.19	− 4.4	−4.6	33.5	.205	.569	
Natal plum (*Carissa grandiflora*)	78.12	21.88	21.55	4.29	.437	1.196	.563	12.00	None.	12.00	− 5.6	−5.2	32.3	1.03	.918	
Carambola (*Averrhoa carambola*):																
Sweet	100.00	None.	8.22	3.13	.421	.784	.719	3.40	None.	3.40	− .7	− .7	31.3	.755	1.237	
Sour	100.00	None.	8.69	2.84	.408	.309	.....	5.25	.16	5.41	− .6	− .8	29.5	.314	.992	
Tamarind (*Tamarindus indica*)	48.28	51.72	69.51	17.68	1.823	11.329	3.431	18.74	2.58	21.32	+ 3.3	.0	31.2	.851	5.615	
Pomegranate (*Punica granatum*):																
Whole fruit	56.06	43.94	26.33	10.14	.591	.122	1.488	12.21	None.	12.21	− 3.2	−3.2	30.2	.477	5.297	
Pulp	46.88	53.12	17.52	1.98	.735	.137	.525	15.00	1.07	16.07	− 2.6	−4.0	30.0	.304	.329	
Poha (*Physalis peruviana*)	100.00	None.	17.86	6.78	.733	1.009	.....	2.67	5.97	8.64	+ 6.4	−1.2	30.7	.331	4.730	
Do	100 00	None.	17.76	7.09	.829	1.214	2.006	2.25	5.49	7.74	+ 6.6	− .4	30.5	.298	3.828	

[1] Determined by copper reduction method.

[2] Hawaii Sta. Rpt. 1910, p. 47.

Composition of some Hawaiian fruits, nuts, etc.—Continued.

Kind of fruit.	Edible portion.	Waste.	Total solids.	Insoluble solids.	Ash.	Acids as H_2SO_4.	Protein.	Sugars.			Polarization.			Fat.	Fiber.	Hydrolyzable carbohydrates other than sucrose.
								Reducing.	Sucrose.	Total.	Direct.	Invert.	Temperature.			
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*° V.*	*° V.*	*° C.*	*Per ct.*	*Per ct.*	*Per cent.*
Ohelo berry (*Vaccinium reticulatum*)	100.00	None.	8.51	.....	0.175	0.485	0.431	3.42	0.32	3.74	− 1.2	−1.6	33.0	.....	.....	.....
Hitchcock berry (*Rubus* sp.)	100.00	None.	13.22	7.01	.397	.534	1.300	5.48	None.	5.48	− .8	− .4	30.5	0.391	3.953	.....
Liberian coffee (*Coffea liberica*):																
Pulp	.....	.....	28.21	13.34	1.630	.255	2.863	5.30	None.	5.30	+ .4	+ .4	31.9	.288	3.315	.....
Bean	.....	.....	45.18	35.52	1.578	.069	5.338	2.56	3.94	6.50	+ 3.6	−1.4	31.6	.685	14.703	.....
Prickly pear (*Opuntia tuna*):																
Red	78.96	21.04	16.54	2.40	.579	None.	.938	12.75	.55	13.30	+ .3	− .4	30.0	.240	1.296	.....
Green	.....	.....	19.66	4.69	.404	.181	.981	13.42	None.	13.42	− 1.4	− .8	31.0	.232	2.791	.....
Longan (*Nephelium longan*)	58.52	41.48	17.61	.....	.....	.....	1.419	5.99	2.35	8.34	+ 1.0	−2.0	30.3	.452	.638	.....
Allspice (*Pimenta officinale*)	100.00	None.	28.28	18.42	1.110	.392	1.581	11.09	None.	11.09	− 3.4	−3.1	33.8	2.033	4.040	.....
Wi apple (*Spondias dulcis*)	65.00	35.00	14.53	2.48	.442	.478	.500	7.09	3.45	10.54	+ 1.3	−3.1	30.5	.286	.853	.....
Hog plum (*Spondias lutea*)	47.50	52.50	11.47	.83	.655	.980	1.375	9.41	None.	9.41	− 1.5	− .8	29.7	.565	1.165	.....
Kamani (*Terminalia catappa*)	63.94	36.06	19.52	8.62	.963	.162	.788	7.78	.94	8.72	− .4	−1.6	31.2	.229	3.300	.....
Carryong (*Brachychiton* sp.)	36.84	63.16	13.78	2.21	.890	.715	1.525	1.31	7.72	9.03	+ 7.4	−2.4	31.3	.620	.808	.....
Noni (*Morinda citrifolia*)	59.93	40.07	10.97	3.16	.838	.303	.631	3.37	.14	3.51	− 1.1	.....	.....	.260	1.052	.....
Oil palm (*Elæis guineensis*):																
Fruit	49.76	50.24	28.70	.....	.....	.431	1.088	4.45	None.	4.45	− 1.2	−1.3	33.0	.258	8.907	.....
Algaroba (*Prosopsis juliflora*):																
Meal	100.00	None.	92.51	50.17	3.535	.331	9.863	3.07	27.59	30.68	+26.4	−9.2	27.3	1.160	24.578	.....
Coconut (*Cocos mucifera*)	26.40	73.60	54.66	31.43	1.020	.129	4.206	Trace.	6.41	6.41	+ 5.4	−2.8	29.5	33.406	5.450	.....
Macadamia nut (*Macadamia ternifolia*)	.....	.....	92.99	72.14	1.622	.098	.....	Trace.	2.67	2.67	+ 1.8	−1.6	30.6	66.730	1.920	.....
Kukui nut (*Aleurites triloba*)	12.1	87.9	92.86	.....	3.05	.....	19.88	.....	.....	.....	.....	.....	.....	66.250	1.39	[1] 1.40
Cashew nut (*Anacardium occidentale*)	29.48	70.52	93.22	.....	2.588	.....	14.437	.....	.....	.....	.....	.....	.....	41.568	1.273	.....

[1] Total hydrolyzable material.

STUDY OF THE RIPENING PROCESS OF THE CHINESE BANANA AND THE PAPAYA.

It is of considerable interest to compare the composition and ripening process of two such fruits as the banana and the papaya. The banana, grown in the Tropics and commonly known in the Temperate Zone because it stands transportation so well, is characterized by its high carbohydrate content. The papaya, not so well known in the North, resembles the average fruit which contains little nourishment but is of value for its high water content, fruit acids, and enzyms. The papaya is characterized by an enzym allied to pepsin, which is considered to be an aid to digestion.

In this study of the fruits a few microscopic tests were first made on the unripe and the ripe samples. The banana when green and tested for starch by iodin turned en masse to an intensely blue-black color, but when ripe only a few granules scattered here and there turned dark, showing the great decrease in starch on ripening. A test for tannin on cross sections of both the green and ripe banana, using ferric chlorid solution, showed tannin to be arranged in a narrow line around the outer margin of the fruit and along the three divisions that radiate from the center.

In contrast to the banana the green or ripe papaya showed with iodin no indication of starch to the unaided eye, except for an almost imperceptible circle where the stem had been cut from the fruit. Under the microscope a few grains of starch could be discerned in the fruit itself. There was apparently no tannin present in either the green or the ripe papaya.

The chemical analysis of the two fruits was made according to the official methods,[1] modified in a few instances, as stated below.

Sucrose was determined by polarization before and after inversion. Reducing sugars were determined according to the volumetric method of Munson and Walker.[2] In every case lead subacetate was used as a clarifying reagent.

Hydrolyzable carbohydrates were determined by boiling the substance with 200 cubic centimeters water and 20 cubic centimeters hydrochloric acid (specific gravity 1.125). Starch in the banana was determined by digestion with diastase and after filtration hydrolysis of an aliquot with hydrochloric acid.

COMPOSITION OF THE CHINESE BANANA.

A bunch of Chinese bananas was picked while the fruit was very green and slightly undersized and hung up in a room near the laboratory, where it was allowed to ripen. An analysis was made of the very green fruit at a period when the peel adhered closely to the flesh.

[1] U. S. Dept. Agr., Bur. Chem. Bul. 107 (rev.). [2] Ibid., p. 42.

When the remaining bananas showed a slight yellow tint, a sample was again taken for analysis. Another sample was analyzed when the fruit was entirely ripe.

The determination of reducing sugar made on the water solution of the entirely green banana presented some difficulty, as the sugar content was extremely low, and some gum, which could not be precipitated with lead subacetate, caused a greenish-yellow precipitate to form on boiling with the Fehling solution. This difficulty was overcome by boiling the sugar sample with 95 per cent alcohol, according to the method of E. M. Bailey,[1] filtering, and evaporating the alcohol from the solution, to which lead subacetate was then added and the reducing sugars determined.

The results obtained on the first bunch of bananas are given under "a" in the table on page 73.

As the banana forms a gummy mass with water, it is almost impossible to separate sugars entirely from the starch and other carbohydrates by means of water. In some analyses both starch and the hydrolyzable carbohydrates were determined in the whole sample without first extracting the sugars. It was found that sugars were somewhat decomposed on boiling with the dilute acid, so that an error occurred by this method and the total hydrolyzable carbohydrates found in the ripe fruit was less than the total sugars found in the water solution.

A second bunch of green bananas was therefore obtained and allowed to ripen for analysis. In the samples from this bunch the sugars were first extracted with boiling alcohol[2] and the starch and hydrolyzable carbohydrates determined in the residues. It was found by this method that the sugars could be separated rapidly from the banana, since alcohol does not form the gummy mass with the material as does water. The starch was not separated from the dextrins before treatment with diastase and subsequent hydrolysis, but a separate determination of gums, soluble in water, showed them to be present to the extent of 0.59 per cent in the green and 0.43 per cent in the ripe fruit. In the ripe fruit the determination of gums was made on the residue after extraction with boiling alcohol; and as the boiling alcohol may easily have extracted certain dextrins, there may have been a higher percentage of gums than determined. Under "b" in the table are shown the results obtained by extraction with alcohol.

The results from both samples show that the total solids decrease slightly during the ripening process. The insoluble solids are almost as high as the total solids in the green banana, but decrease very rapidly on ripening and in the ripe fruit amount to less than 3 per

[1] Jour. Amer. Chem. Soc., 34 (1912), No. 12, p. 1729. [2] E. M. Bailey, loc. cit.

cent. The ash is high throughout and does not change appreciably. The acid content is but a few tenths of a per cent and appears to reach its maximum when the fruit is half ripe, after which it decreases. The protein is fairly high and remains constant.

Quite striking is the change in starch and sugars, during the process of ripening of the banana. When green, the starch is exceedingly high, amounting to about 20 per cent, while the sucrose and reducing sugars amount to a few tenths of a per cent. At the half-ripe stage, the sugars have increased several per cent and in about the same proportion that the starch has decreased. In the fully ripened stage the sugars have increased greatly and the starch has almost disappeared.

The hydrolyzable carbohydrates, other than starch or sucrose, are small in amounts.

Fat occurred in small quantities, increasing from 0.025 per cent in the green fruit to 0.180 per cent in the ripe. Fiber was also present in small amounts.

In the water solution after boiling, none of the usual tannin reactions were obtained. Tannin was, therefore, not determined.

COMPOSITION OF THE PAPAYA.

The papayas used for study were obtained directly from one tree, each on the day analyzed, and were chosen by the horticulturist, who is familiar with the indications of ripening fruit. The fruits were analyzed at the fully ripe stage and at several immature stages, the very green ones being quite undersized. Those which were analyzed five months before ripeness were about half the size of the mature papaya. The yellow tint does not appear in the fruit until about three weeks before full ripeness. As the fruit contained practically no starch according to qualitative test, this determination was not made, but the total hydrolyzable carbohydrates were determined by boiling the material with dilute hydrochloric acid solution and subtracting from the total the reducing sugars found in the water solution. The results are shown in the table on page 73.

It is at once seen that the total solids are low throughout the ripening process and increase as the fruit ripens. The insoluble solids are about 3 per cent in the green fruit and decrease to about 1 per cent in the ripe fruit. The ash, acid, and protein occur in small quantities and are quite constant. The fruit contains not more than a trace of sucrose. The reducing sugars in the green fruit, however, amount to over 2 per cent but increase rapidly as the fruit increases in size and approaches ripeness. The hydrolyzable carbohydrates are almost nil, and fat, fiber, and undetermined matter occur only in small amounts. It is logical to conclude, therefore, that, as the fruit

when green has no store of carbohydrates upon which to draw, it must obtain its sugars by translocation from the trunk of the trees.

In comparing the banana with the papaya it is noted that the banana contains higher percentages of total solids, carbohydrates, protein, acid, and ash, and is altogether a more substantial fruit. It is of interest to note that the total solids decrease in the banana during the ripening process but increase considerably in the papaya. The banana contains large amounts of starch and other carbohydrates when green. It may, therefore, be separated from the tree at that time and on ripening still contain a normal amount of sugar due to the hydrolysis of its starch. In the papaya no such store of food is held.

It is also interesting to note that the banana contains sucrose and reducing sugars. The papaya, on the other hand, has practically no sucrose but considerable reducing sugars. The fat content is more constant in the papaya during ripening and the fiber is higher than in the banana.

In both fruits the acid-sugar ratio is low.

Some of the changes in the composition of the Chinese banana and of the papaya during the ripening process are shown in the accompanying table.

Composition of the Chinese banana and the papaya at different stages of ripeness.

Stage of ripeness.	Edible portion.	Waste.	Total solids.	Insoluble solids.	Ash.	Acids as H_2SO_4.	Protein.	Sugars.			Polarization.			Starch by diastase method.	Hydrolyzable carbohydrates other than starch or sugar.	Fat.	Fiber.	Undetermined matter.
								Reducing.	Sucrose.	Total.	Direct.	Invert.	Temperature.					
Chinese banana.																		
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	°*V.*	°*V.*	°*C.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Green (a)	57.48	42.52	23.51	16.25	0.871	0.196	2.013	0.15	0.31	0.46	+ 1.6	+1.2	25.3	17.38	1.16	0.025	0.276	1.13
Green (b)	.....	.....	28.51	25.25	.891	.114	1.275	.10	.53	.63	+ .6	− .1	25.3	19.97	1.23	.055	.370	3.97
Half ripe (a)	63.64	36.36	21.98	10.78	.948	.343	1.838	4.93	4.17	9.10	+ 4.2	−1.2	26.2	5.02	2.28	.151	.335	1.96
Half ripe (b)	57.76	42.24	27.56	14.90	.921	.320	1.331	3.53	7.31	10.84	+ 6.8	−2.6	28.3	7.93	1.64	.091	.314	4.17
Ripe (a)	70.00	30.00	21.28	2.45	.955	.245	1.788	8.18	8.48	16.66	+ 7.9	−3.2	23.7	None.	None.	.180	.253	1.20
Ripe (b)	67.00	33.00	24.47	2.66	.883	.156	1.119	7.41	11.26	18.67	+10.4	−4.2	25.6	.43	.49	.257	.309	2.16
Papaya.																		
5 months before ripeness	71.00	29.00	6.48	3.28	.621	.065	.800	2.15	.23	2.38	+ 1.5	+1.2	30.7	.....	.26	.205	.873	1.28
5–6 weeks before ripeness	80.97	19.03	6.13	2.38	.451	.045	.381	2.88	None.	2.88	+ 1.0	+1.2	28.0	.....	.49	.186	.602	1.09
4 weeks before ripeness	81.24	18.76	6.13	2.31	.427	.045	.388	2.81	.23	3.04	+ .7	+ .4	27.8	.....	.01	.188	.692	1.34
3 weeks before ripeness	81.13	18.87	6.26	2.46	.471	.026	.306	2.93	None.	2.93	+ .7	+ .8	26.7	.....	.45	.208	.716	1.1
2 weeks before ripeness	78.73	21.27	6.45	2.49	.425	.044	.306	4.13	.47	4.60	+ .6	.0	31.0	.....	.00	.261	.581	.23
8 days before ripeness	84.65	15.35	8.92	2.37	.508	.033	.356	5.99	None.	5.99	− .2	− .2	30.0	.....	.12	.163	.654	1.10
1 day before ripeness	84.99	15.01	10.68	1.18	.514	.059	.463	7.82	.47	8.29	− .6	−1.2	27.5	.....	.....	.168	.592	.65
Entirely ripe	83.39	16.61	10.59	1.05	.565	.059	.388	8.02	None.	8.02	− .2	.0	31.0	.....	.00	.186	.693	.68